# INSTRUCTION MANUAL

FOR THE

# NAVIGATION AID TEST SET

# TYPE 235A

BOONTON RADIO CORPORATION

P. O. Box 390 Boonton, New Jersey

U. S. A.

MP MASTER

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1M/CP/62

Printed in U.S.A.

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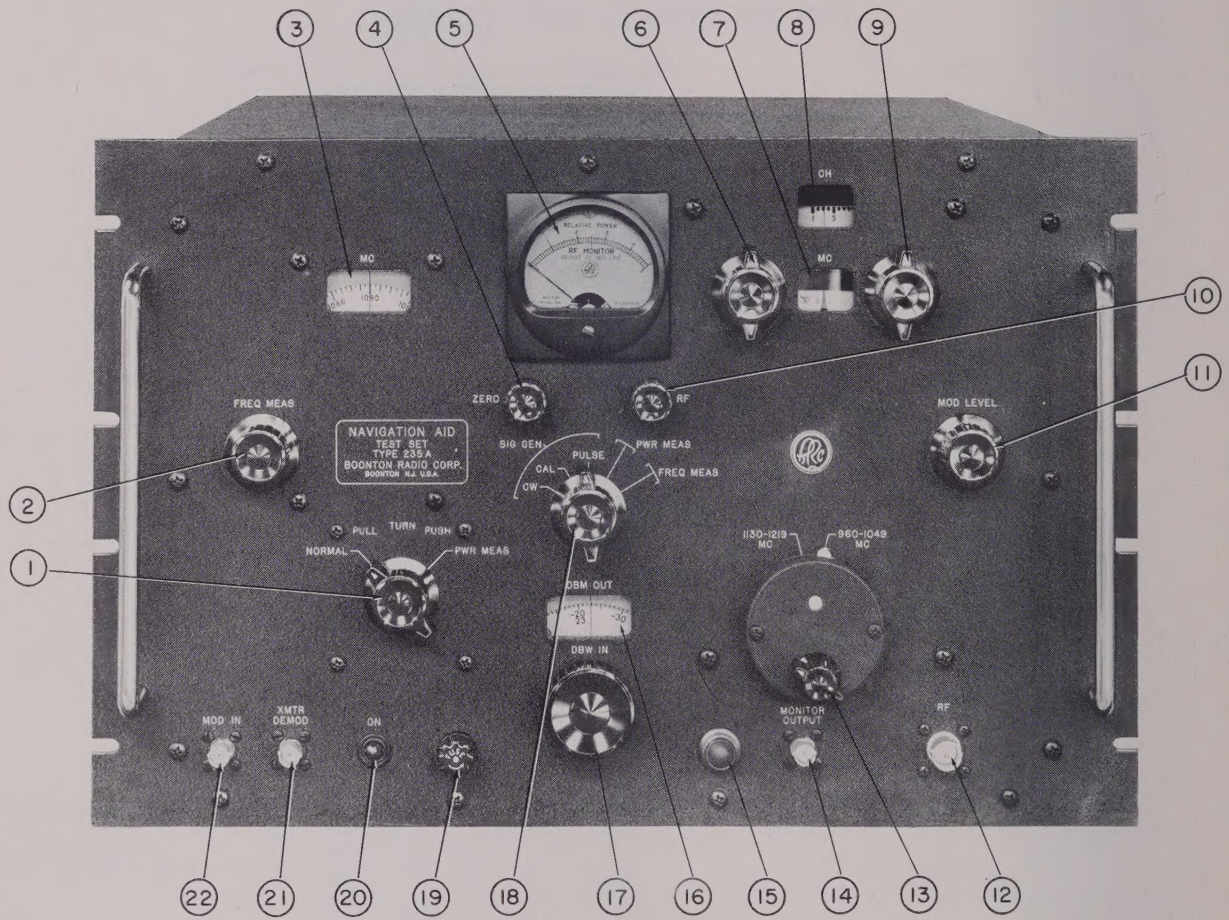



***Figure 1. Front Panel Controls, Indicators, and Connectors***

1. NORMAL-PWR-MEAS Switch
2. FREQ MEAS Control
3. Wavemeter (MC) Dial
4. ZERO Control
5. Panel Meter
6. Left-hand (Tens) Frequency Selector Knob
7. Frequency (MC) Dials
8. Channel (CH) Dial
9. Right-hand (Units) Frequency Selector Knob
10. RF Control
11. MOD LEVEL Control
12. RF Connector
13. Frequency Range Switch
14. MONITOR OUTPUT Connector
15. Pilot Lamp
16. Attenuator Dial
17. Attenuator Control
18. Function Selector Switch
19. FUSE
20. Power Switch
21. XMTR DEMOD Connector
22. MOD IN Connector

# SECTION I
# DESCRIPTION

## GENERAL

The Navigation Aid Test Set Type 235A is specifically designed for the testing and calibration of DME (Distance Measuring Equipment) and ATC (Air Traffic Control) transponder aircraft systems. The instrument is completely self contained, except for modulators, and consists of a crystal-controlled signal generator, precision power meter, direct reading frequency meter, and RF envelope pulse detector. Modulating signals can be obtained from the Collins Radio Type 578D-1 DME Bench Test Set and the Type 578X-1 Transponder Bench Test Set.

The crystal-controlled signal generator provides discrete output frequencies covering all 126 ground Tacan channels, plus 39 additional frequencies for checking ATC transponders. The power meter reads the output of both DME and ATC transponder units and the frequency meter measures the reply frequency of the ATC transponders. The RF envelope pulse detector permits analysis of the RF signal on an external oscilloscope.

## FRONT PANEL CONTROLS & INDICATORS

All of the controls necessary for the operation of the Navigation Aid Test Set are arranged in convenient functional order on the front panel of the instrument. The controls and their functions are described below and shown in Figure 1.

### Power Switch

The power switch applies voltage to the power supply when set to the ON position.

### NORMAL–PWR MEAS Switch

The NORMAL position of this switch is used for all measurements except the comparative peak-power measurement. The PWR MEAS position is used in conjunction with the variable attenuator to determine peak power output of the DME or ATC equipment. To operate the switch, pull out, turn, and push in again.

### Function Selector Switch

This switch provides the necessary circuit connections for signal generator, peak-power measurement, and frequency measurement operation.

### SIG GEN Section

CW—In CW position the external pulse modulation signal is disconnected and connections are provided for balancing the thermistor bridge and setting the correct input level to the piston attenuator.

CAL—In CAL position the external positive pulse modulation signal is applied to the cathode of the final doubler to completely interrupt the CW output for the duration of each pulse. This demodulated, interrupted CW may be observed as a relative amplitude on the front panel meter or on an external oscilloscope for a peak pulse calibration of the calibrated CW output level.

PULSE—In PULSE position the final doubler is biased to cut-off and the external positive pulse modulation is applied to the grid of the final doubler through the MOD LEVEL control. The modulation level is adjusted so that the detected peak pulse amplitude is the same as the amplitude observed for the interrupted CW signal in CAL position. This peak pulse output level is referenced to the thermistor bridge calibration of the CW output level.

### PWR MEAS

In PWR MEAS position the peak power output of the RF signal generator is compared with the accurately attenuated external transmitter output pulse in the same detector and at the same level. The measurement is made by adjusting the output of the RF signal generator, with the piston attenuator, for the same detected peak amplitude observed for the transmitter output and reading the transmitter peak power in dbw on the DBW IN dial.

### FREQ MEAS

In FREQ MEAS position the pulse voltmeter is connected to the wavemeter and the wavemeter is manually tuned, by means of the FREQ MEAS control, to the output frequency of the ATC transponder.. Tuning is accomplished by peaking the pointer on the front panel meter and the frequency is read on the MC dial to the left of the panel meter.

### Frequency Range Switch

This switch is used to select the desired operating frequency range. The low-frequency range is from 960 to 1049 MC and the high-frequency range is from 1130 to 1219 MC.

### Channel and Frequency Selectors

These selectors are in the upper right-hand corner of the instrument. The left-hand selector knob is a coarse frequency control which selects the ground Tacan channel and the signal generator output frequency in 10-MC increments. The channel number is indicated on a drum dial in the CH window and the frequency control (right-hand selector knob) selects the ground Tacan channel and the output frequency in 1-MC increments. The fine setting is indicated as the last digit of the frequency indication on the left-hand dial in the MC window. Channel selection is also made by the frequency range switch.

### Channel (CH) Dial

This dial is operated by the coarse (left-hand) and fine (right-hand) frequency selector knobs. The dial

indicates ground Tacan channels 1 to 63 for one position of the frequency range switch and channels 64 to 126 for the other position of the frequency range switch.

### Frequency (MC) Dials

The left-hand MC dial is operated by the coarse (left-hand) frequency selector knob and is calibrated in megacycles from 1130 to 1200. The right-hand MC dial is operated by the fine (right-hand) frequency selector and is calibrated in megacycles from 1 to 9.

### MOD LEVEL Control

This control varies the level of the positive pulse modulation applied from the external modulator to the grid of the final doubler.

### FREQ MEAS Control

This control is used to tune the wavemeter to the output frequency of the ATC transponder. The frequency is read on the wavemeter dial in the upper left-hand corner of the instrument.

### Wavemeter (MC) Dial

The MC dial in the window in the upper left-hand corner of the instrument indicates the output frequency of the transponder (ATC) under test. The dial is operated by the FREQ MEAS control and is calibrated in 0.5 megacycle increments from 1070 to 1110 megacycles.

### Attenuator Control

The attenuator control drives the precision piston attenuator and adjusts the RF output of the signal generator as indicated on the DBM OUT dial. For peak-power measurements, this control adjusts the output of the signal generator to provide a comparative signal which is read out on the DBW IN dial.

### Attenuator Dial

This dial is operated by the attenuator control. The DBM OUT scale indicates the RF output of the signal generator and is calibrated in decibels referred to 1 milliwatt into 50 ohms from −10 to −100 dbm. The DBW IN scale indicates the output of the signal generator for peak-power measurements as referred to the precision RF attenuator, and is calibrated in decibels above 1 watt into 50 ohms from 17 to 33 dbw. Outputs of from 23 to 33 dbw can be observed with the internal pulse voltmeter. Outputs of from 17 to 23 dbw can be read using an external 100 mv/cm oscilloscope.

### ZERO Control

This control is used to set the electrical zero of the panel meter before the electrical measurements are made.

### RF Control

This control is used to adjust the CW RF level out of the signal generator to red line as indicated by the panel meter for calibration of the variable piston attenuator.

### Panel Meter

With the function selector set to the CW position, the panel meter is connected to the thermistor bridge and is used in conjunction with the ZERO and RF controls to adjust and indicate thermistor bridge balance and RF level of the signal generator. When the function selector is set to the CAL, PULSE, or PWR MEAS positions, the panel meter is connected to the pulse voltmeter circuit and operates as a peak voltmeter to indicate relative power. With the function selector set for FREQ MEAS operation, the panel meter operates as a peak indicator to permit tuning the wavemeter to the ATC frequency.

## FRONT PANEL CONNECTORS

### MOD IN Connector

The MOD IN connector is used to connect the input from the pulse modulator to the 235A. Positive pulses (minimum 7.5V, Maximum 20V peak) only should be connected to this connector. For best accuracy of measurements (for DME only), pulse height should be 8 ±0.5V peak.

### XMTR DEMOD Connector

The XMTR DEMOD connector makes available at the front panel of the 235A the demodulated RF pulses from the ATC transponder or DME unit under test.

### MONITOR OUTPUT Connector

This connector makes available at the front panel of the 235A a demodulated RF signal from the output of the signal generator or from the input of the ATC transponder or DME radio set.

### RF Connector

The RF connector makes available at the front panel of the 235A the output of the signal generator for signal generator measurements. The connector is coupled to the input of the power meter and wavemeter for peak-power and transponder frequency measurements. The antenna output of the ATC transponder or DME is connected to this jack.

### FUSE

A FUSE connected in the AC line is located on the front panel (1.5 amp. for 115V input, 0.75 amp. for 230V input).

# SECTION II
# SPECIFICATIONS

## SIGNAL GENERATOR

### Radio Frequency Characteristics

**RF RANGE:**

(A) 962 to 1024 MC in increments of 1 MC (Ground Tacan Channels 1-63).

(B) 1151 to 1213 MC in increments of 1 MC (Ground Tacan Channels 64-126).

(C) 1011 to 1049 MC in increments of 1 MC (ATC Transponder).

**RF ACCURACY:** ± 0.005% (60°-100°F)

**RF OUTPUT:**

Range: —10 to —100 dbm*
*Across external 50-ohm load at output jack.

Accuracy: ± 1 db

Impedance: 50 ohms

VSWR: 1.2 max.

Spurious Output:
All *Spurious RF output voltages within ± 25 Mc of desired signal are at least 30 db below the desired signal.
*excluding harmonics of desired signal.

**RF LEAKAGE:** Less than —112 dbm.

### Pulse Modulation Characteristics

**PM SOURCE:** External

**PM RISE TIME:** Less than 0.14 μsec* (1011-1049 MC)
Less than 0.33 μsec** (962-1213 MC)
*responding to ideal square wave.
**responding to 0.30 μsec overshootless pulse.

**PM FALL TIME:** Less than 0.14 μsec* (1011-1049 MC)
Less than 0.33 μsec** (962-1213 MC)
*responding to ideal square wave
**responding to 0.30 μsec fall time overshootless pulse.

**PM OVERSHOOT:** Less than 5%* (1011-1049 MC)
Less than 5%** (962-1213 MC)
*responding to ideal square wave
**responding to 0.30 μsec rise time overshootless pulse.

**PM LINEARITY:** Better than ± 0.5 db from 0 db to —9 db of envelope peak.

**PULSE/CW RATIO:** 40 db*
*60 db at 1030 MC

**EXTERNAL PM REQUIREMENTS:** 7.5 volts peak minimum positive pulse into 100 ohms.

## POWER METER

### Radio Frequency Characteristics

**RF RANGE:** 960 to 1219 MC

**RF INPUT:**

Range: + 17 to + 33 dbw* (50 to 2000 watts)
* + 17 to + 23 dbw employing external 100 MV/CM oscilloscope.

Accuracy: ± 1.5 db*
*for 2000 4-pulse replies per second (ATC Transponder) and all DME interrogating conditions.

Impedance: 50 ohms

VSWR: 1.2 max.

## FREQUENCY METER

### Frequency Characteristics

**RF RANGE:** 1070 to 1110MC

**RF ACCURACY:** ± 0.5 MC

**RF CALIBRATION:** Increments of 0.5 MC throughout range

## RF ENVELOPE PULSE DETECTOR

### Radio Frequency Characteristics

**RF RANGE:** 962 to 1213 MC

### Detector Characteristics

**DET. OUTPUT LEVEL:**
0.5 volts peak min. open circuit*
*for the following input conditions
(a) Xmtr. Demodulator +17 dbw from external transmitter.
(b) Power Measuring Detector +30 dbw from external transmitter
(c) Signal Generator Detector — entire range —10 to —100 dbm.

**IMPEDANCE:** 150 ohms

**DET. BANDWIDTH:**
7 MC for 3db bandwidth*
*for load < 70 pf

**DET. RISE TIME:**
Less than 0.06 μsec*
*responding to ideal square wave

**DET. OVERSHOOT:**
Less than 2%*
*responding to ideal square wave

## ACCESSORIES FURNISHED

Type 521-A Output Cable
Type 522-A Patching Cable

## TUBE AND SEMICONDUCTOR COMPLIMENT

| Tubes | Semiconductors |
|---|---|
| 1—5651 | 1—1N465 |
| 3—5670 | 2—1N1763 |
| 1—5687 | 2—1N1764 |
| 2—5876 | 3—1.5M7.5Z5 |
| 1—6080 | 2—1.5M82Z10 |
| 1—GL6299 | 3—MA424 |
| 1—6AH6 | 1—MA425 |
| 2—6AK5 | |
| 2—6AL5 | |
| 1—6AN4 | |
| 1—6AS6 | |
| 1—6AU6 | |
| 1—6AU8 | |
| 1—12AT7 | |
| 1—12AX7 | |

### PHYSICAL CHARACTERISTICS

**MOUNTING:** Designed for standard 19" rack mounting

**FINISH:** Gray wrinkle, engraved panel (other finishes available on special order).

**DIMENSIONS:** Height 12-7/32; Width 19"; Depth 16-27/32".

**WEIGHT:** Net: 80 lbs. Gross Export: 145 lbs. Gross Domestic: 95 lbs. Legal Export: 95 lbs.

**POWER REQUIREMENTS**

**235A:** 105-125/210-250 volts, 50-420 cps: 100 watts.

# SECTION III
# OPERATING INSTRUCTIONS

## GENERAL

The Navigation Aid Test Set Type 235A is designed for use with DME and ATC modulators, such as the Collins Radio Company, type 578D-1 DME Bench Test Set and the Type 578X-1 Transponder Bench Test Set, for complete bench testing of the DME and ATC airborne equipment. This section lists the auxiliary equipment necessary for these tests and gives the procedures necessary for:

1. Installation of the 235A.
2. Interconnecting the 235A, modulators, DME and ATC equipment.
3. Initial setup of the 235A, modulators, DME and ATC equipment.
4. Measurement of the various DME and ATC equipment characteristics.

The measurement procedures describe the control settings and sequence of control operations and cite some typical requirements. Actual measurement requirements and tolerances will depend upon the particular DME and ATC equipment being tested and therefore, should be taken from the appropriate DME and ATC equipment handbooks.

## AUXILIARY EQUIPMENT REQUIRED

In addition to the DME and ATC modulators, the following equipment is required for complete bench testing of the DME and ATC equipment.

1. Dual trace Oscilloscope—Risetime: 0.015 μsec. Bandwidth: Up to 24 MC. Sweep Speed: 0.02 μsec/cm
2. VTVM—H-P Model 410B or equivalent

## INSTALLATION

The 235A may be operated on a bench or installed in a standard 19-inch rack. Rubber feet are provided for bench operation. If the instrument is to be operated in an enclosed rack, it is recommended that the dust cover be removed to aid in heat dissipation.

## DME MEASUREMENTS

### Interconnections for DME Measurements

For the performance of measurements on DME equipment, the 235A should be interconnected with the DME modulator, the DME equipment, and the dual channel oscilloscope as shown in Figure 2. Connect the 235A to a 105-125 or 210-250 volt, 50-420 cps power source.

NOTE: The 235A is shipped from the factory wired for 105 to 125-volt, 50 or 60 cps operation. However, the instrument may also be operated from a 210 to 250-volt, 50 or 60 cps power source. The Input Voltage Switch (S601 in Figure 40) should be positioned for the desired input voltage. It will be necessary to remove the instrument cover in order to gain access to the switch. When operating on 210 to 230 volts, the 1-1/2 ampere fuse (F600) should be replaced with a 3/4 ampere fuse. The modulator, DME equipment, and oscilloscope should be connected to appropriate power sources as specified in the manufacturer's handbooks. Turn on the equipment and allow 1 hour for warm up.

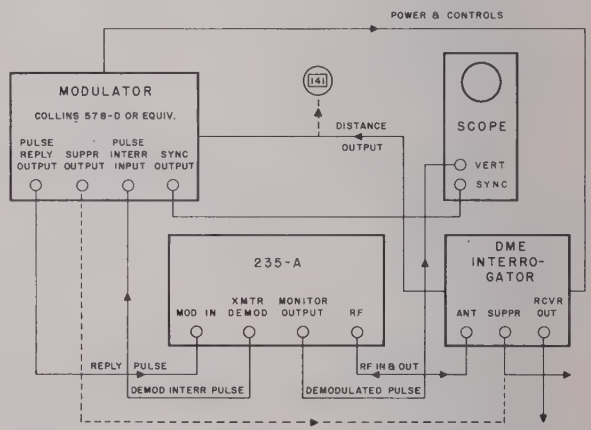



*Figure 2. Interconnections for DME Measurements*

### Initial Setup for DME Measurements

Before the DME measurement procedures are performed, the front panel controls of the 235A, modulator, and DME equipment should be preset as follows.

1. Select the desired channel and frequency on the 235A with the channel and frequency selectors.
2. Set up the DME modulator as follows:
   a. Set the search limit switch for normal operation.

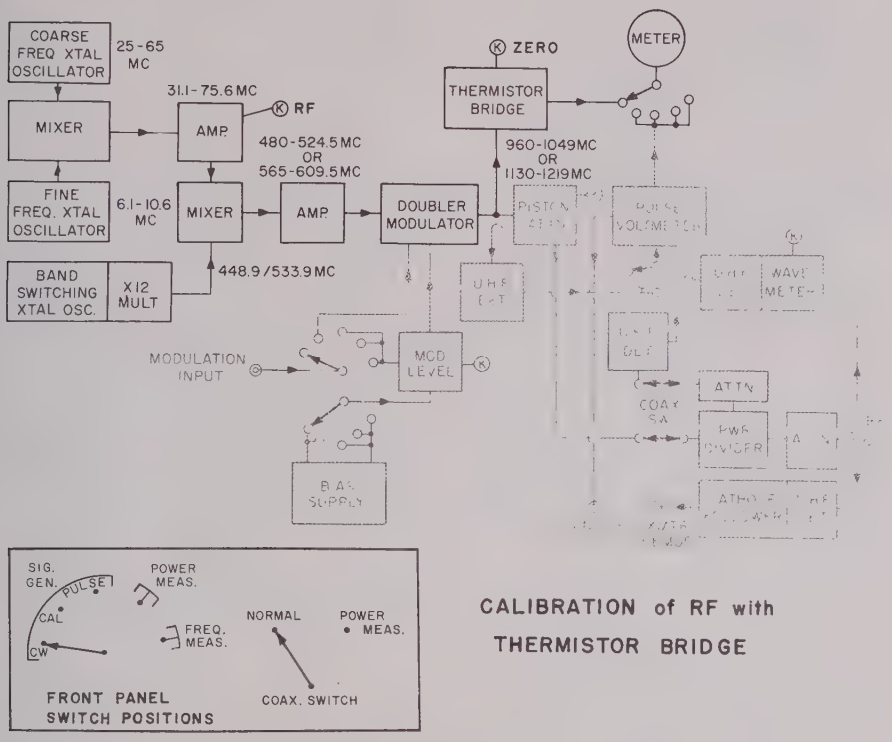



***Figure 3. Calibration of RF with Thermistor Bridge***

b. Set the pulse spacing switch for 12-microsecond spacing.
c. Set the sync selector switch to squitter.
d. Set the squitter rate switch to 700.
e. Set the distance switch for 0 miles.
f. Set the reply efficiency switch for 70% efficiency.
g. Pulse amplitude 8 ±0.5V.

3. Set up the 235A controls as follows (Fig. 3):

CAUTION: To avoid an erroneous red line meter reading during the setting up of the 235A with the NORMAL-PWR MEAS switch in the NORMAL position, any transmitter attached to RF connector J516 should be set to "standby", turned off, or disconnected. Be sure to energize or reconnect transmitter for equipment measurements.

a. Set the function selector to CW.
b. Turn the RF controls to the maximum counterclockwise position.
c. Adjust the ZERO control until the panel meter pointer is aligned with the 0 mark on the meter scale.
d. Adjust the RF control until the panel meter pointer is aligned with the red line on the meter scale.
e. Set the function selector switch to the CAL position and note the panel meter reading (Fig. 4).
f. Set the function selector to the PULSE position and adjust the MOD LEVEL control for the same meter reading observed in step e.

NOTE: The MOD LEVEL control should be adjusted to the first point at which the reading is observed when the control is turned in a clockwise direction. Additional turning of the control may provide the same reading observed in step e, but will cause the final doubler to draw grid current.

### Transmitter Power (DME)

Two methods are outlined for measuring DME transmitter power. The first method is recommended over the second for the following reasons. When all measurements are made with the 235A operating at one frequency (at the particular frequency suggested), the frequency characteristic of the piston attenuator is eliminated and the overall system errors are minimized. It should be noted here that, while the power measure detector may compare signals as much as 126 mc apart, its frequency characteristic is sufficiently flat so as to introduce negligible error. In addition, and a prime consideration, is the elimination of tedious and time consuming control manipulations.

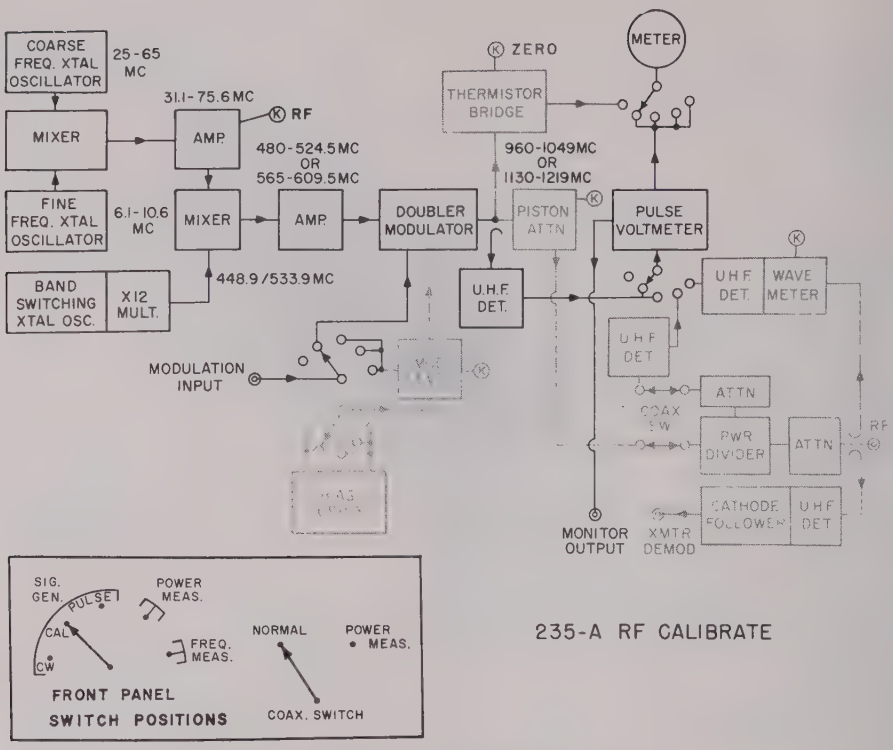



***Figure 4. RF Calibrate***

### *Calibrated Pulse Voltmeter Power Measurement*

1. For the usual case, where the user is interested in checking several DME radio sets for power output relative to some minimum acceptable level, the calibration procedure is as follows:
   a. Set the 235A to channel 63.
   b. With the NORMAL-PWR MEAS switch in the PWR-MEAS position, apply a modulating signal from the 578D-1 Modulator to the 235A. For best accuracy, the modulating signal should be at a 700 cps squitter rate and its amplitude should be 8 $\pm$0.5V. This amplitude can be obtained by adjustment of R205 on the back of the 578D-1.
   c. Set the 235A attenuator dial to indicate the desired power level and adjust for normal pulse operation. (See Initial Setup for DME Measurements—Section III.)
   d. Set the function switch to the PWR MEAS position and record the pulse voltmeter reading. This reading corresponds to the minimum acceptable DME power level.
   e. With the function switch in the PWR MEAS position, return the NORMAL-PWR MEAS switch to the NORMAL position.
   f. Connect the DME radio set to the 235A and read the pulse voltmeter. Any reading below that obtained in (d) above is an indication of less than the minimum acceptable level. The DME equipment may be switched from channel to channel for rapid power measurements, without additional manipulation of the 235A controls.
2. Where it is desired to know the actual levels of power, this can be easily accomplished by extending the calibration procedure given in (1) above to include several 235A attenuator dial settings corresponding to the expected range of power measurements. This data can be plotted and will result in an essentially linear relationship of pulse voltmeter divisions versus input power, as shown by the typical curve of Figure 5.

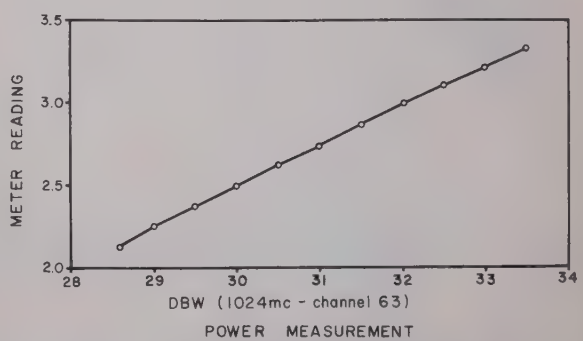



***Figure 5. Typical Power Measurement vs. Meter Calibration Curve***

3. Additional improvement in accuracy can be obtained by relating the calibration of the pulse voltmeter, as described above, to an external peak-power calibrator.
   a. Calibrate the pulse-voltmeter, as above, at channel 63 (1024 mc).
   b. With the 235A set to channel 63, set up the controls to measure power.
   c. Apply a signal from a DME operating at channel 1 (1025 mc) and note the pulse voltmeter reading.
   d. Measure the DME output power with the external peak power measuring device.
   e. Apply the meter and power readings, obtained in (c) and (d), to the pulse voltmeter calibration in (a). Because of the near linear relationship of pulse voltmeter divisions to input power, it is only necessary to move the point or curve up or down as required by this additional calibration.

NOTE: Due to the normal changes inherent in crystal diode detectors during usage, it is suggested that the pulse voltmeter be recalibrated each day.

### *Direct Comparison Power Measurement*

1. Set the function selector switch to the PWR MEAS position (Fig. 6).
2. Set the channel selectors on the 235A and the modulator to desired channel.
3. Note the relative power level reading on the panel meter.
4. Set the NORMAL—PWR MEAS switch to PWR MEAS (Fig. 7)

CAUTION: It is important that the NORMAL—PWR MEAS switch be properly seated to avoid the introduction of higher than normal VSWR within the system.

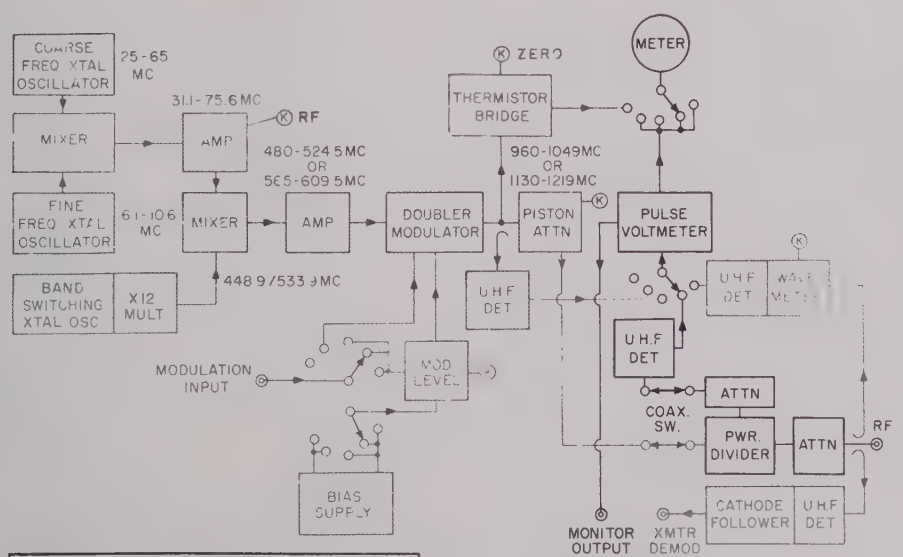
5. Adjust the attenuator control to obtain the same meter reading as in step 3.
6. Read the transmitter power on the DBW IN dial.

### Interrogator Pulse Characteristics (DME)

Connect the dual channel oscilloscope to the XMTR DEMOD connector on the 235A front panel and observe the following pulse characteristics.

1. Pulse Rise Time.
2. Pulse Fall Time.
3. Pulse Duration.
4. Pulse Repetition Rate.
5. Pulse Coding.
6. Pulse Top.

These characteristics should conform to the requirements specified in the DME equipment handbook.




PEAK POWER MEASUREMENT STEP I

DME

***Figure 6. Peak Power Measurement, Step 1, DME***

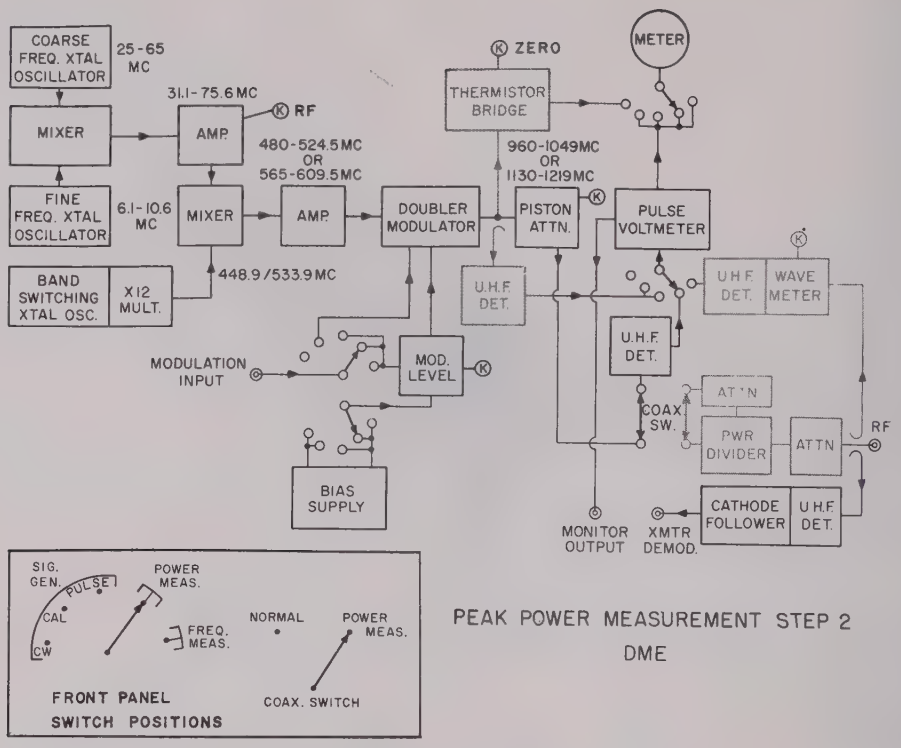



***Figure 7. Peak Power Measurement, Step 2, DME***

**Receiver Sensitivity (DME)**

1. Set the channel selector on the 235A and the modulator to channel 1. The receiver frequencies for the TACAN channels are given in Table 1.
2. Perform steps 3a through 3f of the initial setup procedure for DME measurements.
3. Set the attenuator control to a reading required for maximum sensitivity as specified by the DME equipment manufacturer.
4. Switch the distance switch on the modulator to 18 for a time sufficient to cause the DME equipment to begin searching, then return the switch to 0 and observe that the DME equipment will lock on at 0.
5. Refer to the DME equipment handbook for specific sensitivity requirements.

**AGC Performance**

1. Perform steps 1 and 2 of the Receiver Sensitivity procedure.
2. Connect a VTVM to the AGC test jack in the DME equipment.
3. Using the attenuator control to adjust the output, observe that the dc voltage indicated on the VTVM is within the limits specified in the DME handbook for specific dbm settings.

**Search Speed and Search Range Limit**

For search speed and range limit requirements, refer to the DME equipment handbook.

**Decoder Selectivity**

1. Select any channel on the modulator and the 235A.
2. Set the attenuator control for a reading specified by the DME equipment manufacturer for the decoder selectivity check.
3. Set the NORMAL—PWR MEAS switch to NORMAL and the function selector to PULSE (Fig. 8).

CAUTION: It is important that the NORMAL—PWR MEAS switch be properly seated to avoid the introduction of higher than normal VSWR within the system.

4. The DME equipment should lock on at 0 and go into search for the pulse spacing control settings and after the time intervals specified in the DME equipment handbook.

**Identification Tone**

1. Select any channel on the modulator and the 235A.
2. Set the attenuator control to a reading of —87dbm (or for any reading specified by the DME equipment manufacturer for the identification tone check) on the DBM OUT dial.

3. Plug a head set into the identification output on the modulator.
4. Switch the squitter rate switch back and forth between the 0 and identification positions to key the identification. An unambiguous keyed tone should be heard in the headset.

**Distance Accuracy**

1. Select any channel on the modulator and the 235A.
2. Set the pulse spacing switch on the modulator to

| TACAN* CHANNEL NUMBER | DME** G to A (mc) | DME A to G (mc) | VOR/ILS/VHF | |
|---|---|---|---|---|
| 1 | 962 | 1025 | 134.4 | |
| 2 | 963 | 1026 | 134.5 | |
| 3 | 964 | 1027 | 134.6 | |
| 4 | 965 | 1028 | 134.7 | |
| 5 | 966 | 1029 | 134.8 | |
| 6 | 967 | 1030 | 134.9 | |
| 7 | 968 | 1031 | 135.0 | |
| 8 | 969 | 1032 | 135.1 | |
| 9 | 970 | 1033 | 135.2 | |
| 10 | 971 | 1034 | 135.3 | |
| 11 | 972 | 1035 | 135.4 | |
| 12 | 973 | 1036 | 135.5 | |
| 13 | 974 | 1037 | 135.6 | |
| 14 | 975 | 1038 | 135.7 | |
| 15 | 976 | 1039 | 135.8 | |
| 16 | 977 | 1040 | 135.9 | |
| 17 | 978 | 1041 | 108.0 | |
| 18 | 979 | 1042 | 108.1 | |
| 19 | 980 | 1043 | 108.2 | |
| 20 | 981 | 1044 | 108.3 | |
| 21 | 982 | 1045 | 108.4 | |
| 22 | 983 | 1046 | 108.5 | |
| 23 | 984 | 1047 | 108.6 | |
| 24 | 985 | 1048 | 108.7 | |
| 25 | 986 | 1049 | 108.8 | |
| 26 | 987 | 1050 | 108.9 | |
| 27 | 988 | 1051 | 109.0 | |
| 28 | 989 | 1052 | 109.1 | |
| 29 | 990 | 1053 | 109.2 | |
| 30 | 991 | 1054 | 109.3 | |
| 31 | 992 | 1055 | 109.4 | |
| 32 | 993 | 1056 | 109.5 | |
| 33 | 994 | 1057 | 109.6 | |
| 34 | 995 | 1058 | 109.7 | |
| 35 | 996 | 1059 | 109.8 | |
| 36 | 997 | 1060 | 109.9 | |
| 37 | 998 | 1061 | 110.0 | |
| 38 | 999 | 1062 | 110.1 | |
| 39 | 1000 | 1063 | 110.2 | |
| 40 | 1001 | 1064 | 110.3 | |
| 41 | 1002 | 1065 | 110.4 | |
| 42 | 1003 | 1066 | 110.5 | |
| 43 | 1004 | 1067 | 110.6 | |
| 44 | 1005 | 1068 | 110.7 | |
| 45 | 1006 | 1069 | 110.8 | |
| 46 | 1007 | 1070 | 110.9 | |
| 47 | 1008 | 1071 | 111.0 | |
| 48 | 1009 | 1072 | 111.1 | |
| 49 | 1010 | 1073 | 111.2 | |
| 50 | 1011 | 1074 | 111.3 | |
| 51 | 1012 | 1075 | 111.4 | |
| 52 | 1013 | 1076 | 111.5 | |
| 53 | 1014 | 1077 | 111.6 | |
| 54 | 1015 | 1078 | 111.7 | |
| 55 | 1016 | 1079 | 111.8 | |
| 56 | 1017 | 1080 | 111.9 | |
| 57 | 1018 | 1081 | 112.0 | |
| 58 | 1019 | 1082 | 112.1 | |
| 59 | 1020 | 1083 | 112.2 | |
| 60 | 1021 | 1084 | 133.3 | |
| 61 | 1022 | 1085 | 133.4 | |
| 62 | 1023 | 1086 | 133.5 | |
| 63 | 1024 | 1087 | 133.6 | |

Short Range Limited Range

* Read on 235A CH Dial

| TACAN* CHANNEL NUMBER | DME** G to A (mc) | DME A to G (mc) | VOR/ILS/VHF |
|---|---|---|---|
| 64 | 1151 | 1088 | 133.7 |
| 65 | 1152 | 1089 | 133.8 |
| 66 | 1153 | 1090 | 133.9 |
| 67 | 1154 | 1091 | 134.0 |
| 68 | 1155 | 1092 | 134.1 |
| 69 | 1156 | 1093 | 134.2 |
| 70 | 1157 | 1094 | 112.3 |
| 71 | 1158 | 1095 | 112.4 |
| 72 | 1159 | 1096 | 112.5 |
| 73 | 1160 | 1097 | 112.6 |
| 74 | 1161 | 1098 | 112.7 |
| 75 | 1162 | 1099 | 112.8 |
| 76 | 1163 | 1100 | 112.9 |
| 77 | 1164 | 1101 | 113.0 |
| 78 | 1165 | 1102 | 113.1 |
| 79 | 1166 | 1103 | 113.2 |
| 80 | 1167 | 1104 | 113.3 |
| 81 | 1168 | 1105 | 113.4 |
| 82 | 1169 | 1106 | 113.5 |
| 83 | 1170 | 1107 | 113.6 |
| 84 | 1171 | 1108 | 113.7 |
| 85 | 1172 | 1109 | 113.8 |
| 86 | 1173 | 1110 | 113.9 |
| 87 | 1174 | 1111 | 114.0 |
| 88 | 1175 | 1112 | 114.1 |
| 89 | 1176 | 1113 | 114.2 |
| 90 | 1177 | 1114 | 114.3 |
| 91 | 1178 | 1115 | 114.4 |
| 92 | 1179 | 1116 | 114.5 |
| 93 | 1180 | 1117 | 114.6 |
| 94 | 1181 | 1118 | 114.7 |
| 95 | 1182 | 1119 | 114.8 |
| 96 | 1183 | 1120 | 114.9 |
| 97 | 1184 | 1121 | 115.0 |
| 98 | 1185 | 1122 | 115.1 |
| 99 | 1186 | 1123 | 115.2 |
| 100 | 1187 | 1124 | 115.3 |
| 101 | 1188 | 1125 | 115.4 |
| 102 | 1189 | 1126 | 115.5 |
| 103 | 1190 | 1127 | 115.6 |
| 104 | 1191 | 1128 | 115.7 |
| 105 | 1192 | 1129 | 115.8 |
| 106 | 1193 | 1130 | 115.9 |
| 107 | 1194 | 1131 | 116.0 |
| 108 | 1195 | 1132 | 116.1 |
| 109 | 1196 | 1133 | 116.2 |
| 110 | 1197 | 1134 | 116.3 |
| 111 | 1198 | 1135 | 116.4 |
| 112 | 1199 | 1136 | 116.5 |
| 113 | 1200 | 1137 | 116.6 |
| 114 | 1201 | 1138 | 116.7 |
| 115 | 1202 | 1139 | 116.8 |
| 116 | 1203 | 1140 | 116.9 |
| 117 | 1204 | 1141 | 117.0 |
| 118 | 1205 | 1142 | 117.1 |
| 119 | 1206 | 1143 | 117.2 |
| 120 | 1207 | 1144 | 117.3 |
| 121 | 1208 | 1145 | 117.4 |
| 122 | 1209 | 1146 | 117.5 |
| 123 | 1210 | 1147 | 117.6 |
| 124 | 1211 | 1148 | 117.7 |
| 125 | 1212 | 1149 | 117.8 |
| 126 | 1213 | 1150 | 117.9 |

** Read on 235A MC Dial

**TABLE 1. Tacan Channel Selection Frequencies**

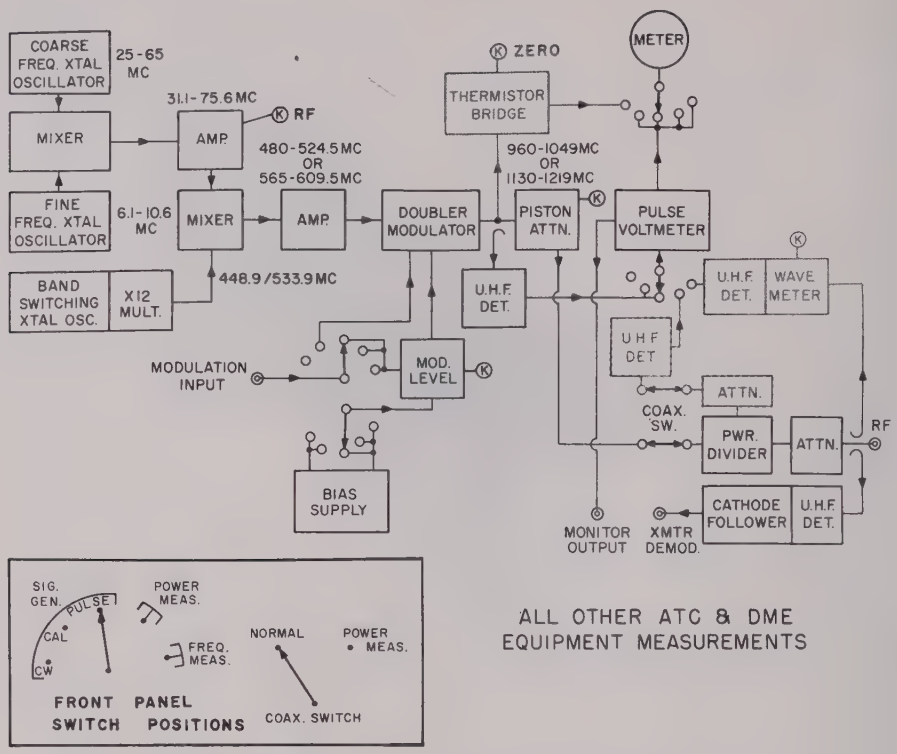



*Figure 8. All Other ATC and DME Equipment Measurements*

12 and the squitter rate to 2700.

3. Set the distance switch on the modulator for 0 miles and allow the DME equipment to lock on.
4. Take a distance reading, integrating out small angular variations in the units dial on the modulator. The reading should be within the accuracy specified in the DME equipment handbook.
5. Repeat for distance switch settings of 18, 36, 54, 72, 90, 108, 126, 144, 162, and 180, referring to the DME equipment handbook for required accuracies for these distance settings.

## ATC MEASUREMENTS

### Interconnections for ATC Measurements

For the performance of measurements on ATC equipment, the 235A should be interconnected with the ATC modulator, the ATC equipment, and the dual channel oscilloscope as shown in Figure 9. Connect the 235A to a 105-125 or 210-250 volt, 50-420 cps power source.

NOTE: The 235A is shipped from the factory wired for 105 to 125-volt, 50 or 60 cps operation. However, the instrument may also be operated from a 210 to 250-volt, 50 or 60 cps power source. The Input Voltage Switch (S601 in Figure40) should be positioned for the desired input voltage. It will be necessary to remove the instrument cover in order to gain access to the switch. When operating on 210 to 230 volts, the 1-1/2 ampere fuse (F600) should be replaced with a 3/4 ampere fuse. The modulator, ATC equipment, and oscilloscope should be connected to appropriate power sources as specified in the manufacturer's handbooks. Turn on the equipment and allow 1 hour for warm up.

### Initial Setup for ATC Measurements

Before the ATC measurement procedures are performed, the front panel controls of the 235A, modulator, and ATC equipment should be preset as follows.

1. Select the desired channel on the 235A with the channel selectors.
2. Set up the ATC modulator as follows:
   a. Set the interrogation and transponder mode switches to the "a" position.
   b. Turn the second interrogation delay switch to the off position.
   c. Set the interrogation spacing control to 0.
   d. Set the interrogation spacing control to X10 and the vernier rate control anywhere between 40 and 60.
   e. Turn the second interrogation delay switch to the on position.
   f. Set the sync fixed and variable control for fixed operation.
   g. Turn the side lobe suppressor amplitude control to the off position.
   h. Select the desired transponder reply code with the reply code selectors.

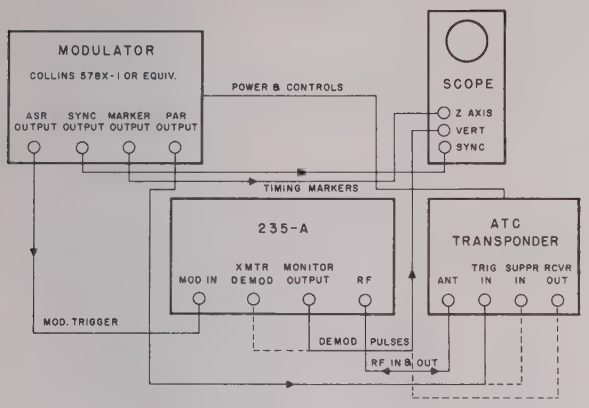



***Figure 9. Interconnections for ATC Measurements***

3. Set the function selectors on the 235A to CW.

CAUTION: To avoid an erroneous red line meter reading during the setting up of the 235A with the NORMAL-PWR MEAS switch in the NORMAL position, any transmitter attached to RF connector J516 should be set to "standby", turned off, or disconnected. Be sure to energize or reconnect transmitter for equipment measurements.

4. Set the RF control to the maximum counterclockwise position.
5. Adjust the ZERO control until the pointer on the panel meter is aligned with 0 on the meter scale.
6. Adjust the RF control until the pointer on the panel meter is aligned with the red line on the meter scale.
7. Set the function selector to the CAL position and note the meter reading.
8. Set the function selector to the PULSE position and adjust the MOD LEVEL control for the same meter reading observed in step 7.

NOTE: The MOD LEVEL control should be adjusted to the first point at which the reading is observed when the control is turned in a clockwise direction. Additional turning of the control may provide the same reading observed in step 7, but will cause the final doubler to draw grid current.

**Receiver Sensitivity (ATC)**

1. Set the frequency range switch to the 960-1049 MC position.
2. Set the frequency selectors for 1030 MC.
3. Perform steps 3 through 8 of the initial setup procedure for ATC measurements.
4. Using the attenuator control to adjust the output level, check that the maximum level needed to give the required percentage of replies to properly encoded interrogations meets the requirement given in the ATC equipment handbook.
5. Switch the power switch on the modulator to the low sensing position and check that the receiver sensitivity is reduced by the number of decibels specified in the ATC equipment handbook.

**Receiver Bandwidth (ATC)**

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Set the attenuator control for a —60dbm reading (or for a reading specified by the ATC equipment manufacturer) on the DBM OUT dial.
3. Connect the oscilloscope to the MONITOR OUTPUT connector on the 235A.
4. Set the frequency selectors on the 235A for 1030 MC (or for any setting specified by the ATC equipment manufacturer).
5. Adjust the attenuator control until the ATC transponder is just triggered at center frequency and note the indication on the DBM OUT dial.
6. Change the signal generator output frequency the desired amount and increase the output level, by means of the attenuator control, until the transponder is just triggered again.
7. Note the reading on the DBM OUT dial. The difference in the attenuator dial indications is the attenuation for the frequency increment used.

**Receiver Dead Time**

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Set the attenuator control for a —60 dbm reading (or for a reading specified for the receiver dead time check in the ATC equipment handbook) on the DBM OUT dial.
3. Rotate the second interrogation delay control on the modulator while observing the second complete pulse reply group on the oscilloscope.
4. The first pulse of the second reply group should occur after the last pulse of the first reply group; within the time limits specified in the ATC equipment handbook.
5. Vary the signal level with the attenuator control and observe that the dead time does not exceed the manufacturer's tolerances.

**Decoder Pulse Width and Side Lobe Suppression**

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Alternately increase and decrease the spacing of the interrogation pulse until the transponder reply is not visible on the oscilloscope. The interrogation pulse spacing should be within the tolerances specified in the ATC equipment handbook.
3. Connect one channel of the oscilloscope to the MONITOR OUTPUT Connector on the 235A and the other channel to the receiver output of the ATC equipment.

4. Vary the second pulse width control on the modulator and determine the minimum and maximum pulse width. The decoder pulse width should be within the tolerances specified in the ATC equipment handbook.
5. Connect one channel of the oscilloscope to the XMTR DEMOD Connector on the 235A and the other channel to the MONITOR OUTPUT Connector, and observe the amplitude of the interrogation pulses.
6. Reduce the amplitude of the second interrogation pulse until the ATC equipment does not reply. Refer to the ATC equipment handbook for the side lobe suppression tolerance.

### Encoder Reply Pulse Position

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Connect the oscilloscope to the XMTR DEMOD Connector on the 235A.
3. With the reply code selectors set for code numbers 00 to 77 (See Table 2), check that the information pulses observed on the oscilloscope correspond to the information pulse data given in Table 2.

| | A B C D E F G H | | | | |
|---|---|---|---|---|---|
| Code No. | Information Pulses Present | Code No. | Information Pulses Present | Code No. | Information Pulses Present |
| 00 | NONE | 30 | BC | 60 | CD |
| 01 | E | 31 | BCE | 61 | CDE |
| 02 | F | 32 | BCF | 62 | CDF |
| 03 | EF | 33 | BCEF | 63 | CDEF |
| 04 | G | 34 | BDG | 64 | CDG |
| 05 | EG | 35 | BCEG | 65 | CDEG |
| 06 | FG | 36 | BCFG | 66 | CDFG |
| 07 | EFG | 37 | BCEFG | 67 | CDEFG |
| 10 | B | 40 | D | 70 | BCD |
| 11 | BE | 41 | DE | 71 | BCDE |
| 12 | BF | 42 | DF | 72 | BCDF |
| 13 | BEF | 43 | DEF | 73 | BCDEF |
| 14 | BG | 44 | DG | 74 | BCDG |
| 15 | BEG | 45 | DEG | 75 | BCDEG |
| 16 | BFG | 46 | DFG | 76 | BCDFG |
| 17 | BEFG | 47 | DEFG | 77 | BCDEFG |
| 20 | C | 50 | BD | | |
| 21 | CE | 51 | BDE | | |
| 22 | CF | 52 | BDF | | |
| 23 | CEF | 53 | BDEF | | |
| 24 | CG | 54 | BDG | | |
| 25 | CEG | 55 | BDEG | | |
| 26 | CFG | 56 | BDFG | | |
| 27 | CEFG | 57 | BDEFG | | |

**TABLE 2. Code Assigment Numbers**

4. Observe that the spacing between the code pulses (B through G) and the framing pulse (a) is correct as per the ATC equipment handbook.
5. Set the identification switch to the on position and observe that the pulse spacing is within the manufacturer's tolerance.
6. Turn the identification switch off. The identification pulse should remain on for the length of time specified in the ATC equipment handbook.

### External PAR Reply

Refer to the Manufacturer's specifications in the ATC equipment handbook for specific test requirements for PAR (Precision Approach Radar) reply.

### AOC Adjustment

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Set the attenuator control for a —40dbm reading (or for a reading specified by the ATC equipment manufacturer) on the DBM OUT dial.
3. Connect a VTVM to the AOC (automatic output control) test jack on the ATC equipment.
4. Refer to the ATC equipment handbook for specific reply rates versus dc level.

### Transmitter Frequency (ATC)

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Set the attenuator control for a —40 dbm reading (or for a reading specified by the ATC equipment manufacturer) on the DBM OUT dial.
3. Rotate the function selector to the FREQ MEAS position (Fig. 10).
4. Adjust the FREQ MEAS control for a maximum indication on the panel meter.
5. The frequency measure (MC) dial should indicate 1090 MC within the tolerance specified in the ATC equipment handbook.

### Transmitter Power (ATC)

CAUTION: To avoid an erroneous red line meter reading during the setting up of the 235A with the NORMAL-PWR MEAS switch in the NORMAL position, any transmitter attached to RF connector J516 should be set to "standby", turned off, or disconnected. Be sure to energize or reconnect transmitter for equipment measurements.

#### *Calibrated Pulse Voltmeter Power Measurement*

Follow procedure as outlined under "Transmitter Power (DME)"

#### *Direct Comparison Power Measurement*

1. Set the function selector to PWR MEAS(Fig.11).
2. Set the desired mode on the modulator.
3. Set the 235A for 1030 MC.
4. Set the interrogation rate as specified by the ATC equipment manufacturer.
5. Note the relative power level on the panel meter.
6. Set the NORMAL—PWR MEAS switch to PWR MEAS(Fig. 12).

CAUTION: It is important that the NORMAL—PWR MEAS switch be properly seated to avoid the introduction of higher than normal VSWR within the system.

7. Adjust the attenuator control to obtain the same reading observed in step 3.
8. Read the power on the DBW IN dial. See Table 3.

### Pulse Characteristics (ATC)

Check the following pulse characteristics with the 235A, modulator, ATC equipment, and oscilloscope interconnected as shown in Figure 9.

1. Pulse rise time.
2. Pulse duration.
3. Pulse decay time.

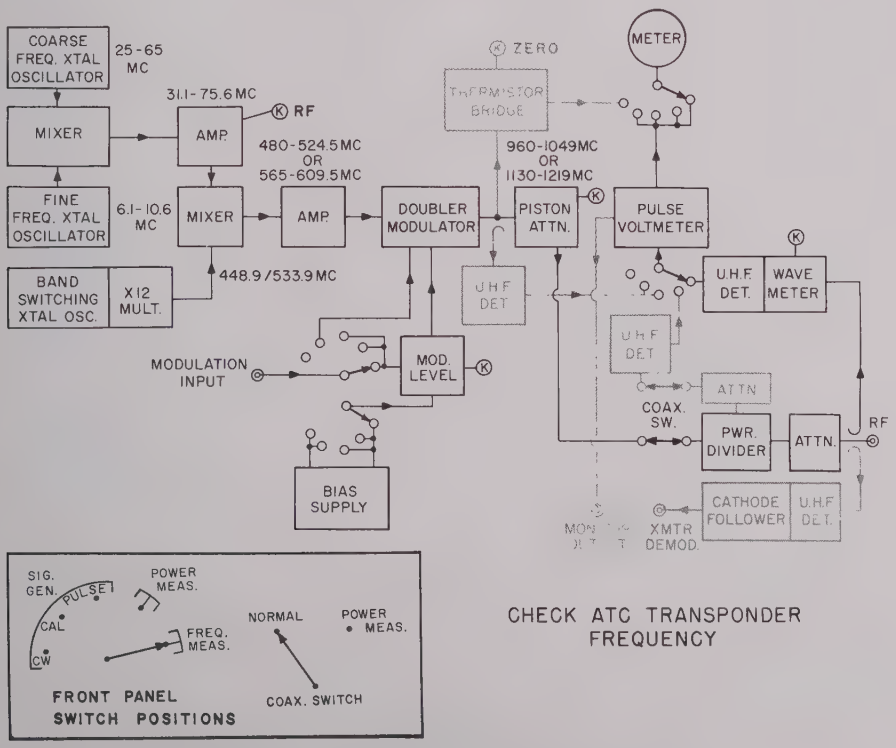
The pulse characteristics should meet the requirements given in the ATC equipment handbook.

### Transponder Delay Time

1. Perform steps 1 through 3 of the ATC receiver sensitivity procedure.
2. Set the attenuator control for a reading of —60 dbm (or for a reading specified in the ATC equipment handbook) on the DBM OUT dial.
3. Connect one channel of the dual channel oscilloscope to the MONITOR OUTPUT connector on the 235A.
4. Connect the second channel of the oscilloscope to the XMTR DEMOD connector.
5. Observe the overall transponder delay between the 50% amplitude points on the leading edges of the second interrogation pulse and the first reply pulse. Refer to the ATC equipment handbook for delay time requirements.

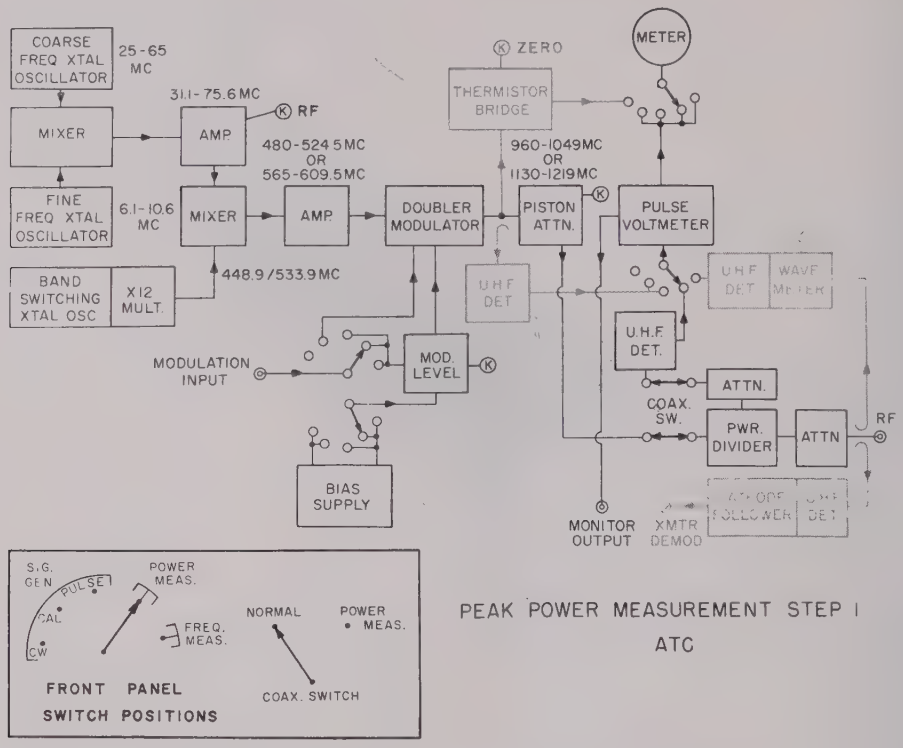
| —DBM* | MICROVOLTS | DBW* | WATTS |
|---|---|---|---|
| 0 | 223,600 | 0 | 1.0 |
| 5 | 125,750 | 7 | 5.01 |
| 10 | 70,710 | 10 | 10.00 |
| 15 | 38,859 | 11 | 12.59 |
| 20 | 22,360 | 12 | 15.85 |
| 25 | 12,575 | 13 | 19.95 |
| 30 | 7,071 | 14 | 25.12 |
| 35 | 3,886 | 15 | 31.62 |
| 40 | 2,236 | 16 | 39.81 |
| 45 | 1,257 | 17 | 50.12 |
| 50 | 707 | 18 | 63.10 |
| 55 | 389 | 19 | 79.43 |
| 60 | 224 | 20 | 100.00 |
| 65 | 126 | 21 | 125.9 |
| 70 | 70.7 | 22 | 158.5 |
| 75 | 38.9 | 23 | 199.5 |
| 80 | 22.4 | 24 | 251.2 |
| 85 | 12.6 | 25 | 316.2 |
| 90 | 7.07 | 26 | 398.1 |
| 95 | 3.89 | 27 | 501.2 |
| 100 | 2.24 | 28 | 631.0 |
| 105 | 1.26 | 29 | 794.3 |
| 110 | .707 | 30 | 1000.0 |
| 115 | .389 | 31 | 1259.0 |
| 120 | .224 | 32 | 1585.0 |
| 125 | .126 | 33 | 1995.0 |
| | | 34 | 2512.0 |
| | | 35 | 3162.0 |
| | | 36 | 3981.0 |
| | | 40 | 10,000.0 |
| *Odb=1 milliwat into 50 ohms | | *Odb=1 watt into 50 ohms | |

**TABLE 3. Decibels versus Microvolts and Watts**



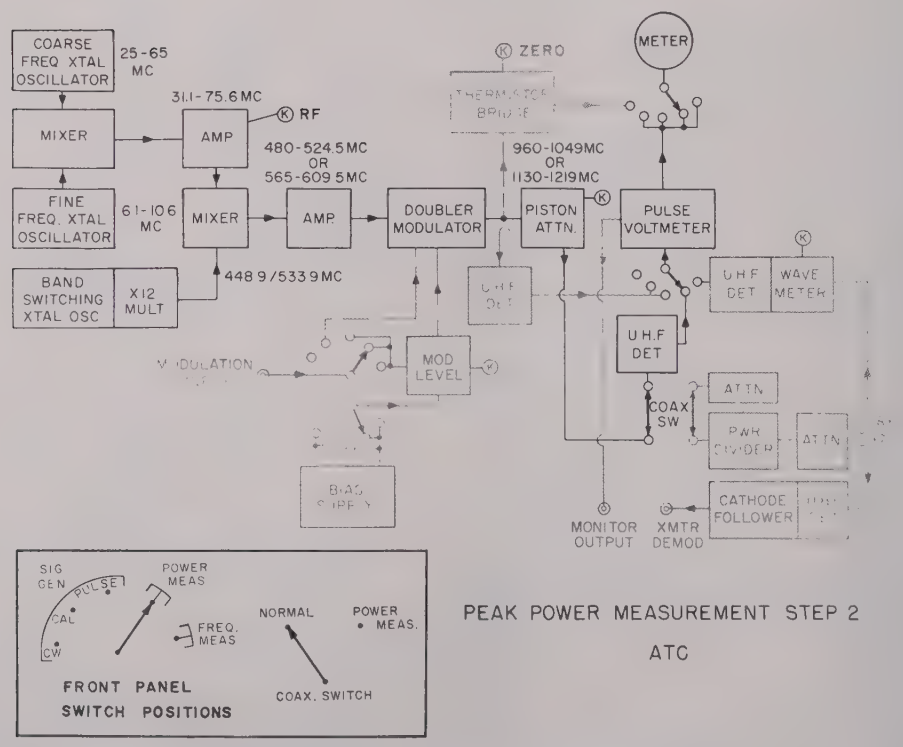

CHECK ATC TRANSPONDER FREQUENCY

*Figure 10. Check ATC Transponder Frequency*




PEAK POWER MEASUREMENT STEP 1
ATC

*Figure 11. Peak Power Measurement, Step 1, ATC*




PEAK POWER MEASUREMENT STEP 2
ATC

*Figure 12. Peak Power Measurement, Step 2, ATC*

# SECTION IV
# THEORY OF OPERATION

## GENERAL

A simplified block diagram of the Navigation Aid Test Set Type 235A is shown in Fig. 13 . This instrument consists of a crystal-controlled RF signal generator; a peak pulse power comparator; a pulse voltmeter; a frequency meter; and a regulated power supply.

## RF SIGNAL GENERATOR

The RF Signal Generator section consists of three crystal controlled oscillators, two mixers, two amplifiers, a buffer, three doublers, and a tripler. The output doubler is modulated and one of the amplifiers is used to control the RF output level.

The 235A employs "crystal saver" frequency synthesis for generating the output frequencies. Frequency multiplication is used in lieu of generating the output frequencies directly in the crystal oscillator. Double heterodyning is employed as it requires fewer crystals; fewer tracked, tuned frequency ranges; and the output frequency depends primarily on only one or two crystals. The crystal oscillator frequencies were chosen with a view to making the most strategic use of state of the art circuit techniques and to effect the best compromise with respect to order and proximity of spurious outputs. It should be noted that in this system the output frequency is always the sum of the crystal frequencies appropriately multiplied.

Referring to the functional block diagram (Fig. 13 ), the receiver test frequencies are generated in three crystal oscillators, heterodyned twice, and doubled in the final stage. The coarse frequency oscillator generates nine frequencies, in 5 mc steps, from 25 mc to 65 mc inclusive, and the fine frequency oscillator generates ten frequencies, in 0.5 mc steps from 6.1 mc to 10.6 mc inclusive. After mixing, the sum of the inputs is extracted, providing a frequency spectrum of 31.1 mc to 76.6 mc inclusive in 0.5 mc steps. A tuned amplifier suppresses the spurious products. The bandswitching oscillator and multiplier generate one frequency for each of two bands; viz., 448.9 mc for the low band and 533.9 mc for the high band. The sum of the outputs of the first mixer and either of the two output frequencies from the bandswitching oscillator is generated in the second mixer, and, after filtering and doubling results in two bands of output frequencies from 960 mc to 1049 mc inclusive and 1130 mc to 1219 mc inclusive in 1 mc steps. Digital readout of the output frequencies, together with a dial readout of the DME channel numbers 1 through 63 for the frequencies 962 mc to 1024 mc inclusive and 64 through 126 for the frequencies 1151 mc to 1213 mc inclusive, are provided on the front panel of the instrument.

There is a difference of 60 mc between the transmitter and receiver frequencies of the ATC Transponder, and a difference of 63 mc between these frequencies in the DME Radio Set. The RF Signal Generator portion of the 235A is designed for receiver frequencies and does not produce the Transponder transmitter frequency. Some of the DME transmitter frequencies are available.

A total of 180 discrete crystal controlled frequencies are generated from 21 crystals, the frequency accuracy of which depends primarily on two crystals in the bandswitching oscillator. The bandswitching oscillator crystals are specified to $\pm 0.0025\%$, the course fre-

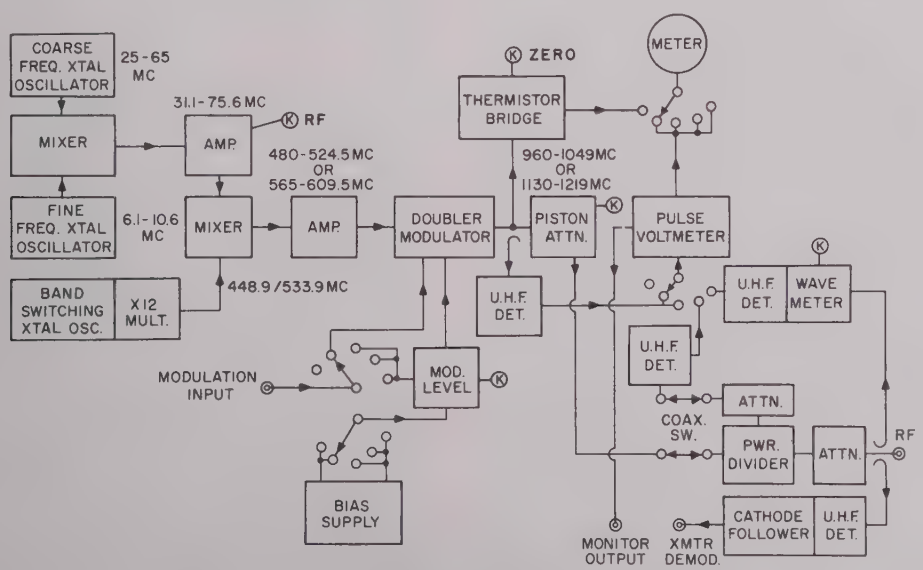



*Figure 13. Block Diagram—Type 235A*

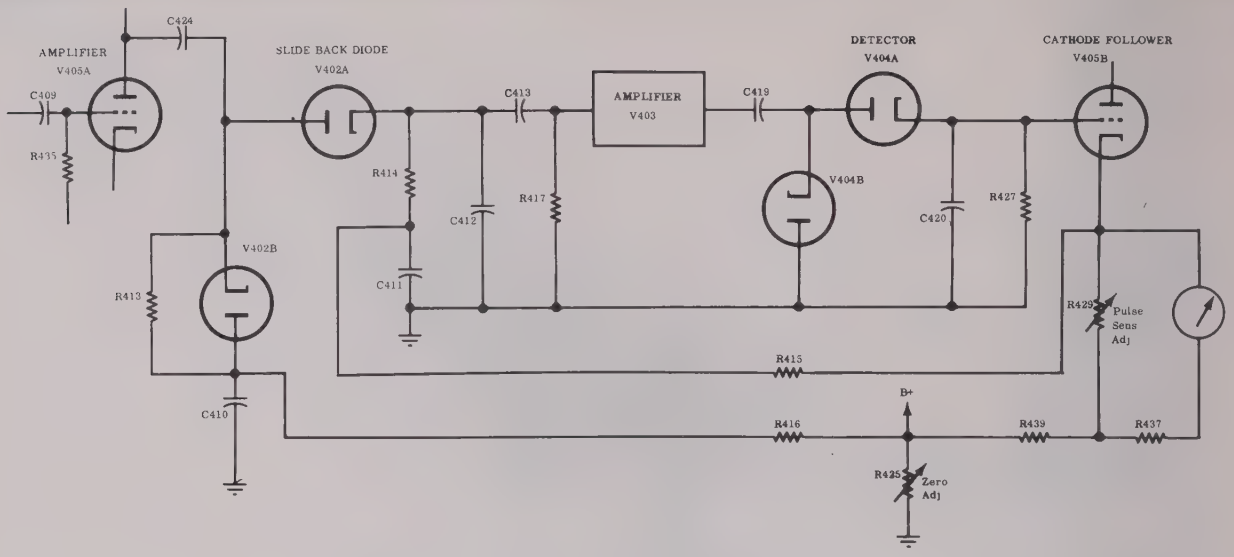



*Figure 14. Basic Circuit—Peak Pulse Voltmeter*

quency oscillator crystals to ±0.005%, and the fine frequency oscillator crystals to ±0.01%. The output frequency accuracy is specified to ±0.005% from 60°F to 100°F.

## PEAK PULSE POWER COMPARATOR

The Peak Pulse Power Comparator is a device for measuring the peak pulse output of the transmitters in the ATC Transponders and DME Radio sets. It consists of a peak pulse voltmeter as a calibrating device and a network containing attenuators, a power divider, a coaxial switch, and a broadband video detector. In principle, this measurement is made by comparing the relative amplitude of the detected transmitter output pulse, after a precisely known amount of fixed attenuation, with the variable calibrated output of the RF signal generator as observed through the same detector. The measurement is made by adjusting the output of the RF signal generator for the same detected peak amplitude as was observed for the transmitter output on the meter, and reading the attenuator dial which is also calibrated in terms of transmitter peak output power over the range of 23 to 33 dbw. Provision is made to utilize an external oscilloscope for this comparison in the range 17 to 33 dbw. The peak power output of the RF signal generator is compared with the accurately attenuated transmitter output pulse in the same detector, at the same level but not normally at the same frequency.

## PULSE VOLTMETER

The Pulse Voltmeter is essentially an automatic, slide-back diode peak reading voltmeter. Preceeding the slide back diode in the circuit are two amplifiers, a cathode follower, and a phase inverter. The cathode follower serves the purpose of supplying a low impedance output for monitoring. The phase inverter is incorporated because positive-going and negative-going pulses can be measured with this circuitry but the input to the slide-back diode must be supplied with positive-going pulses.

The basic circuitry of the peak pulse voltmeter in the 235A is shown in Fig. 14. Referring to the diagram, the operation of the voltmeter is as follows:

With positive pulses at C424, the diode (V402A) conducts. This pulse is amplified by the dual triode (V403) and detected by the diode (V404A). The detected pulses charge the network C420-R427. The positive voltage on the network C420-R427 causes the triode (V405B) to conduct giving a meter reading. The higher the potential on C420 the higher the potential on the cathode of the triode (V405B) which applies a bias back through R415 to R414. This bias voltage buildup will reach approximately the same level as the pulse peak applied to the diode (V402A) thus approaching but not completely cutting it off. This is due to the slight discharge of C420 through R427.

The balance of the circuit performs the following functions: with no incoming pulses the circuit reaches a quiescent state. The zero adjust (R425) almost cuts off the triode (V405B). As a result of the cathode current flow, a very small voltage is fed back through R415 to V402A. This voltage is the zero reference voltage for measuring the pulses. The diode (V405B), acting as a DC Restorer, maintains the reference level when incoming pulses are measured.

With this type of pulse voltmeter, large pulses can be measured quite accurately with no appreciable effect by the PRF.

## WAVEMETER

The Wavemeter in the 235A is of the resonant-cavity, transmission type and is included for the purpose of measuring the transmitter output frequency of the ATC Transponder. The frequency range of the Wavemeter is 1070 mc to 1110 mc in order to accommodate the Transponder operating frequency which

consists of a pulse spectrum centered on 1090 mc. Frequency accuracy of the Wavemeter is ±0.5 mc over the entire range of the instrument. The Wavemeter indicator is the internal peak pulse voltmeter. The design of the voltmeter is such as to be dependent on transmitter power and frequency spectrum, so meter accuracy is not effected by the transmitter PRF.

## POWER SUPPLY

The power supply for the 235A uses conventional type circuitry. It consists of a regulated, full-wave, B supply with several sources of bias. The only unusual part of the power supply is the zener diode regulated, filament supply for the output doubler (V202). Fig. 15 shows the circuit for this source of filament power. In this case a step-down transformer (T200) is connected across the lower resistance side of the high voltage winding of the power transformer (T600). The low voltage output of the T200 transformer is zener-diode regulated.

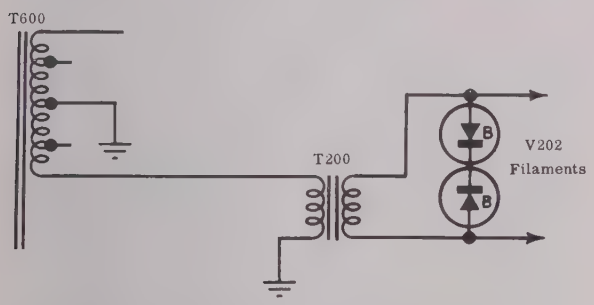



*Figure 15. Regulated Filament Supply V202*

# SECTION V
# OPERATIONAL GUIDE

## OUTPUT FREQUENCY ACCURACY

In the 235A, the crystal saver technique used for generating the output frequencies has the unique feature that the absolute accuracy of the output frequency is largely determined by only two crystals in the UHF Unit each of which is accurate to ±0.0025% (Y200 and Y201). An overall total of twenty-one crystals is used for frequency generation and nineteen of these are in the UHF Unit (ten "Units" crystals of ±0.01% accuracy and nine "Tens" crystals of ±0.005% accuracy). Since the maximum frequency (sum of selected "Units" and "Tens") crystals out of the VHF Unit (75.6 Mc ±0.0057%) is added to the UHF Unit crystal frequencies of either 449 mc and 534 mc, it is easy to see that the frequency error of the VHF crystals will not contribute more than ±0.00083% to the actual output frequency as is shown below:

75.6 mc is generated by adding 10.6 mc ±0.01% and 65 mc ±0.005%.

$$\begin{aligned} 10.6 \text{ mc} \pm 0.01\% &= 10.6 \text{ mc} \pm 1.06 \text{ kc} \\ 65.0 \text{ mc} \pm 0.005\% &= 65.0 \text{ mc} \pm 3.25 \text{ kc} \\ \hline & 75.6 \text{ mc} \pm 4.31 \text{ kc} \\ & = 75.6 \text{ mc} \pm 0.0057\% \end{aligned}$$

524.5 mc is generated by adding 75.6 mc ±4.31 kc and 448.9 mc ±0.0025%

$$\begin{aligned} 448.9 \text{ mc} \pm 0.0025\% &= 448.9 \text{ mc} \pm 11.25 \text{ kc} \\ 75.6 \text{ mc} \pm 4.31 \text{ kc} & \\ \hline & 524.5 \text{ mc} \pm 15.56 \text{ kc} \\ & = 524.5 \text{ mc} \pm 0.003\% \end{aligned}$$

Error added by VHF crystals = 4.31 kc
which is 0.00083% of 524.5 mc

This frequency error is a maximum at the sum of the highest VHF frequencies on the low band (1049 mc). In the initial inspection and calibration of the instrument, a precision frequency counter is used to verify that the crystal frequencies are within the limits specified.

The crystals used in the 235A are selected to maintain specified accuracy over the temperature range of 60° to 100° F. For output frequency accuracy greater than the specified ±0.005%, additional fine adjustment of the tank circuits associated with Y200 and Y201 is possible employing a precision frequency counter such as the HP 524C (See Alignment Procedure).

Pulse modulation of the 235A occurs in the last frequency doubler stage of the UHF Unit which is well isolated from the sources of frequency generation. Therefore, negligible frequency modulation takes place for any expected amplitude modulating waveform.

## OUTPUT LEVEL ACCURACY

Since one of the end uses of the 235A is a source of pulsed RF, it is necessary to provide a means of relating the height of this pulse to a stable CW power level. In the 235A, this is accomplished by indirectly comparing the amplitude of the pulse generated in the PULSE position of the Function Selector Switch to the CW level monitored by the thermistor bridge circuit. This comparison is achieved by first zeroing the Panel Meter with the RF level control in the extreme counter-clockwise position (RF off). Next, with the Function Selector Switch in the CW position, the RF level control is advanced until the Panel Meter reads to the red line. The CW output of the signal generator under these conditions will be within ±1 db of the value read on the attenuator dial measured at the plane of the output connector on the front

panel of the instrument. (For extremely precise measurements, corrections must be made for the losses in the cables connecting the output of the 235A to the unit under test).

The Function Selector Switch is then changed to the CAL position. In this position the pulse output from the Collins 578X1 or Collins 578D1 Modulators is applied to the cathode of the output frequency doubler stage V202. Under these conditions, the carrier output is "chopped off" by the positive pulse applied to the cathode of this stage. For maximum precision of measurement, the duty cycle with which these pulses are applied should be as low as possible. When used with the 578X1 Modulator, the maximum duty cycle (1000 cps—0.95 $\mu$sec pulse width) is so low that negligible error is introduced (under 0.02 db). The 578D1 Modulator, with its greater pulse width (3.5 $\mu$sec pulses per pair) should be adjusted for minimum repetition rate which in the "Search" position, is 700 cycles ("Squitter" condition). This corresponds to a duty cycle of less than 0.5%, which could produce a maximum error of approximately 0.04 db.

The inherent design characteristics of the pulse voltmeter make it ten times more sensitive to positive-going pulses in relation to negative-going pulses. To achieve negligible error, it is essential that the output waveform from the 578X1 and 578D1 Modulators have minimum ripple or sawtooth on the baseline of the pulses. In addition, in the case of the 578D1, it is necessary that R205 be adjusted for 8.0 $\pm$0.5 volts p-p pulse amplitude into the panel jack (MOD IN) on the 235A.

The Function Selector switch is then switched to the PULSE position, the output doubler V202 is biased off, and the modulating signal is applied to its grid to pulse the tube on. The polarity of the pulse voltmeter response is inverted by switching the output of the Phase Inverter (V400B) from the cathode to the plate as shown in Figure 16. Under these conditions, the MOD LEVEL control is adjusted to give the same pulse voltmeter indication as was obtained with the Function Selector switch in CAL position. Slight inaccuracy may result in the transition from negative to positive pulses. However, the careful choice of plate and cathode resistors for V400B minimizes this "turnover" error. (See Replacement of Resistors in the Circuit of V400B, Section VI.) Even this small error can be avoided by making the PULSE —CAL comparison using an oscilloscope connected to the MONITOR OUTPUT jack and adjusting the MOD LEVEL control for a positive pulse equal in amplitude to the negative CAL pulse.

## VSWR

Accuracy of measurement of receiver sensitivity with the 235A, as in the case of all signal generators, is limited by source and load VSWR. While the 235A is specified to have a source VSWR of less than 1.2:1,

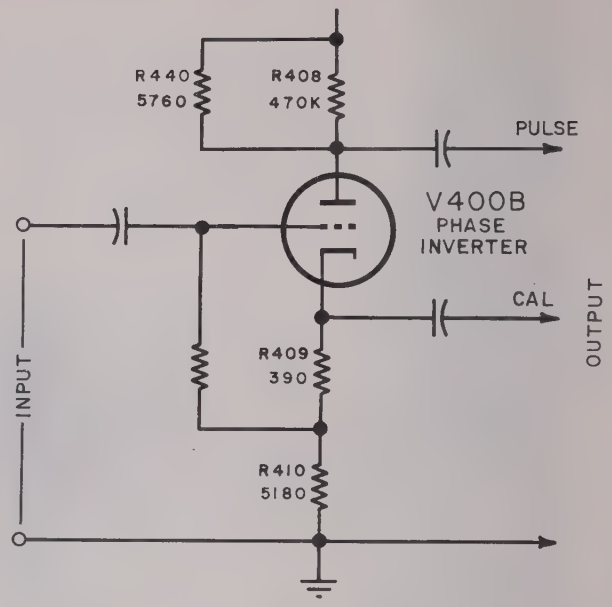



*Figure 16. Phase Inverter—Pulse Voltmeter*

appreciable errors can be caused by the receiver under test. For example, a 235A with a source VSWR of 1.1:1 will have an error in power delivered to a receiver up to 0.64 db if the VSWR of the receiver is 2:1. If it is known that the receiver VSWR is very poor and precise measurement of sensitivity is desired, these errors can be evaluated by use of a low reflection line stretcher to search for the transmission line length that will provide the minimum and maximum reflection error. Alternatively, a low reflection 10 db pad may be inserted at the receiver input to minimize the effects of reflection. (If the transmitter is operating, the pad must of course be capable of handling the average power output of the transmitter.)

## PISTON ATTENUATOR ACCURACY

The Piston Attenuator linearity is controlled by three factors. First, the output VSWR is held to a low value through the use of a compensated piston head, and the attenuator pads used to isolate the piston attenuator pickup loop from the transmitter output. Secondly, the thermistor bridge pickup loop across the mouth of the attenuator tube acts as a mode filter, thus, improving the linearity of the attenuator at high output levels. Finally, the attenuator is designed so that the pickup loop itself never physically comes closer than 3/32" to the open mouth of the attenuator tube at which point the desired mode is 4 db down and undesired modes are appreciably more.

In the upper 5 db of the attenuator range, there is a reaction between the attenuator pickup loop and the RF output meter. On higher channel frequencies this effect may be as much as five meter divisions, and since each division is approximately 0.2 db, this could amount to an error of as much as 1 db if not corrected for by resetting meter to red line. Typical

receiver measurements however, are usually made at the lower end of the attenuator range where this interaction does not exist.

## SIGNAL GENERATOR PULSE SHAPE

The bandwidth of the signal generator modulation circuit and the tuned output stage basically control the rise time of the RF envelope from the 235A. The pulses from the 578X1 Modulator are sufficiently fast that the rise time is almost entirely limited by the bandwidth of the final frequency doubler in the 235A. The observed rise time will be typically 0.14 μsec or less. In the frequency range of the ATC Transponder, negligible overshoot is contributed by the 235A unless the 235A V201 amplifier tuned circuit is seriously detuned (See Maintenance for alignment). In the detuned condition, nonlinear phase characteristics will be introduced causing noticeable overshoot beyond that contributed by the 578X1 Modulator. See waveform Figure 25.

When using the 578D1 Modulator for DME measurements, it will be noted that the pulses are rectangular. This produces negligible error in properly aligned DME Receivers, because the receiver IF bandwidth restricts the pulse shape to approximately that specified by RTCA (for the ground station) by the time it reaches the second detector. Since the power output of the signal generator is measured by peak comparison to a CW power level; as long as the bandwidth of the receiver is wide enough so that the pulse can rise to full amplitude in half the pulse width (1.75 μsec), no significant error in the sensitivity measurement of the receiver will be introduced by this difference in pulse shape. On higher DME channels, especially above channel 63, the alignment of the tuned circuit in the plate of the UHF amplifier (V201) may be slightly detuned from the condition of maximum CW output in order to minimize overshoot on the leading edge of the DME pulses. As shipped from the factory, the overshoot contributed by the 235A, is held to less than 5%.

Pulse shape is important, because the pulse voltmeter in the 235A will respond, in part, to the magnitude of the overshoot; i. e., when setting the amplitude of the pulsed RF output to be equal to that of the negative pulses in the CAL position, using the pulse voltmeter, the amplitude of the flat top of the pulse will be in error by an amount related to the overshoot. In receiver measurements, the receiver second detector will respond to a pulse of amplitude corresponding to the flat top amplitude of the 235A pulse, because the band-restricting IF amplifier system of the receiver will have removed the overshoot. Thus, these measurements will be in error. Should excessive overshoot be present, the errors described can be minimized by making the PULSE-CAL comparison, using an oscilloscope connected to the MONITOR OUTPUT jack and adjusting the MOD LEVEL control for a pulse with a flat top amplitude equal to that of the negative pulse in the CAL position.

## SPURIOUS OUTPUT

At some discrete frequencies a small beat pattern will be noted on the peaks of the pulses. See waveform in Figure 25. This small pattern should be less than 3% of the amplitude of the pulse and results from a product of mixing in the VHF unit that is not completely filtered out. Due to its small amplitude and the fact that it is outside of the receiver passband, it will produce negligible error in setting up the signal generator attenuator and will produce no error in receiver measurement. The chart (Fig. 17) shows

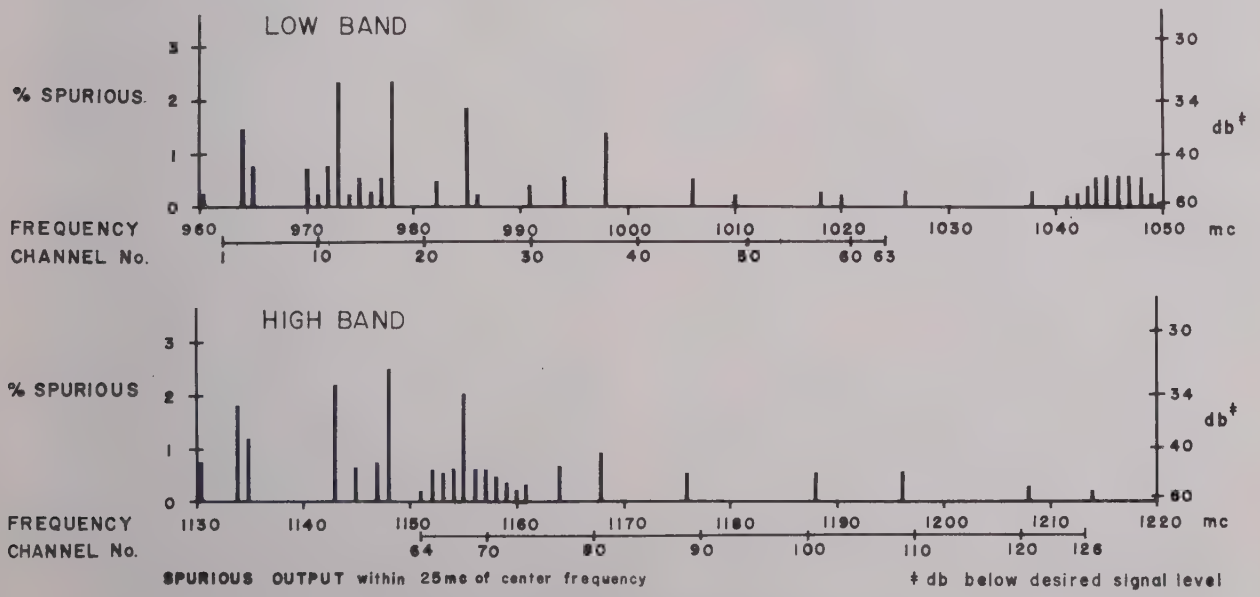



*Figure 17. Spurious Output—Type 235A*

where these spurious signals will typically appear and gives their relative amplitudes.

## POWER MEASUREMENTS

One of the major functions of the 235A is to measure the peak power output of the transmitters associated with the ATC Transponder and DME Interrogator. Since these units have varying duty cycles and different pulse shapes, it is desirable to make this measurement in a manner that is independent of the duty cycle or the repetition rate of the transmitter involved. A crystal detector is therefore used in the 235A which has essentially constant output over the frequency range of 960 to 1215 mc for a constant incident power. In this application, the detector is preceded by a precision attenuator which reduces the output of the transmitter by 63 db. A transmitter developing +33 dbw will have its output attenuated to 0 dbm. The output of the crystal detector is read on the pulse voltmeter in the 235A, which is relatively insensitive to the repetition rate or the width of the incoming pulses, and essentially non-responsive to small duration overshoots.

Since crystal diodes are not extremely stable in long term characteristics, a method of calibrating the crystal detector is needed to take care of these changes. This calibration is provided by utilizing the output of the signal generator piston attenator (0 to −90 dbm) to standardize the crystal detector. The coaxial switch (NORMAL-PWR MEAS) on the 235A permits disconnecting the crystal detector from the precision attenuator and connecting it to the output of the signal generator piston attenuator. Calibration of the pulse voltmeter reading can then be made at any level from +33 dbw (0 dbm) to +23 dbw (−10 dbm). Levels below 23 dbw can be compared by use of an external oscilloscope connected to the MONITOR OUTPUT jack. The accuracy of the power measurement can, of course, be no better than the calibration of the signal generator output, but the design of the 235A permits convenient standardization with an external standard such as an HP 431-A Bolometer Bridge and an HP 478-A Thermistor Mount.

The accuracy of power measurement will be effected by pulse shape to a minor extent. Using the pulse voltmeter, errors of the order of 0.02 db may be introduced. This small error can be reduced by the use of the external oscilloscope where the exact level of comparison can be seen.

VSWR and the basic system design can also affect the absolute accuracy of the power measurement. In the basic system it will be found that the signal generator will not cover all the DME transmitting frequencies although certain channels (1 thru 25 and 106 thru 126) can be measured directly. The same situation is true of the ATC Transponder. However, due to the constancy of output vs. frequency of the 235A power detecting system, it is not necessary to standardize the power measuring detector for each individual frequency. It is recommended that the 235A be calibrated with an external standard on a channel between 60 and 70, preferably Channel 63. For extreme accuracy, calibration should be made at the lower end of the piston attenuator range (See Attenuator Accuracy for explanation). By this method, power measurements, accurate to ±1.0 db, can be made using the pulse voltmeter in the 235A. To maintain this accuracy, it is however necessary to recheck the calibration at least every eight hours. Power measurement accuracies of better than ±1.0 db require the use of a precision external peak power calibrator, carefully standardized to the order of ±0.2 db.

Calibration of the 235A for both power measurement and signal generator output, is made at the front panel jack. Since flexible coaxial cable has appreciable loss per unit length, this loss must be taken into account during the measurement process. Typical losses are 0.09 db per foot at 1 Kmc for RG-8/U cable and 0.22 db per foot at 1 Kmc for RG-58/U cable.

## TRANSMITTER PULSE MEASUREMENT

A high level crystal detector (XMTR DEMOD) is connected to the dual coupler which introduces a 34.5 ±0.5 db loss between the front panel jack and the XMTR DEMOD crystal. This crystal is operated at a level of +28 to +29 dbm in the linear portion of its range when measuring a transmitter delivering 33 dbw. In measuring the characteristics of the ATC transmitter pulse, the bandwidth of the transmitter demodulator is of significance. The 3 db bandwidth of the 235A detector is specified at 7 mc for an external load not exceeding 70 pf; equivalent to three feet of cable. For DME measurements however, much longer cable lengths can be used with negligible effect on the observed pulse shape.

In addition to the bandwidth (Cable should be terminated in 150 ohms for optimum bandwidth), the linearity of the detector is of importance when measuring pulse width. There are two effects which occur with crystals of this type: At low levels (below 0 dbm) these detectors exhibit nearly square-law characteristics; as the level is increased they become more and more linear. At the level of operation of this crystal in the 235A, the exponent representing the law of the detector will run between 1.1 and 1.5.

ARINC characteristic 521B (4-30-58), Attachment 13, (MIL-STD-291), par. 3.2, for DME specifies that measurement of the pulse width shall be done at the half-amplitude point of the RF envelope as measured with a linear detector, and it is therefore necessary to establish this half-amplitude point with some precision if maximum accuracy of pulse width measurement is to be achieved. The recommended method is to insert a precisely known 6 db pad of proper power handling characteristics between the transmitter and the panel jack (RF) of the 235A and the change in oscilloscope reading should be noted with the insertion

of this pad. This technique eliminates the effects of detector law on the measurement. The same precautions on pulse width measurement are not needed to the same degree with the ATC Transponder, as the pulses are more nearly rectangular.

## WAVEMETER ACCURACY

The Wavemeter is provided to measure the frequency of the self-excited oscillator in the ATC Transponder. The frequency range of this wavemeter is 1070 to 1110 mc with an absolute accuracy of ± 0.5 mc and is calibrated in increments of 0.5 mc. The wavemeter is of the transmission type and is connected to the dual coupler block of the precision attenuator. The insertion loss between the wavemeter and the panel jack (RF) is 36 db ± 0.5 db. Thus, the signal level applied to the wavemeter from a 500 watt (+27 dbw) Transponder will be +21 dbm. There is an insertion loss of 18 db in the wavemeter, leaving a signal level of approximately 3 dbm at the FREQ MEAS detector. Since the output of the Transponder consists of a train of very narrow pulses, it is essential to use a transmission type wavemeter, otherwise, a very insensitive indication would be achieved due to the wide pulse spectrum.

In operation, the main function switch is put in the FREQ MEAS position, the external radio set is connected to the panel jack (RF), and the wavemeter dial is rotated for maximum indication on the pulse voltmeter. If a very low power (below 50 watts) transmitter is in use, it may be necessary to use an external oscilloscope connected to the MONITOR OUTPUT jack as an indicating device. It is normal for the pulses to be considerably rounded off by the narrow bandwidth of the wavemeter.

There are two sources of inaccuracies that can affect the wavemeter indication. The first is due to mechanical backlash in the wavemeter and should not exceed 0.2 mc on a new instrument. During the measurement procedure the final frequency indication should always be approached from the same direction to eliminate any error due to backlash. The second source of error is in the resolution of the wavemeter cavity which will provide a repeatability, in the absence of backlash, in the order of ± 0.25 mc. ARINC Characteristic 532C (3-1-61), Section 3.0, par. 3.3.1, specifies that the interrogation frequency shall be 1030 ± 2.5 mc, and the absolute accuracy of ± 0.5 mc is therefore entirely adequate.

NOTE: The figures given for the wavemeter insertion loss are at a frequency of 1030 mc. At frequencies far removed from this value, the sensitivity of the system may be quite different. When checking the output of a low-powered (under 200 watts) transmitter, it is desirable to use an oscilloscope as the indicating device.

# SECTION VI
# MAINTENANCE

## GENERAL

The 235A is a complex yet compact instrument. In spite of its complexity, if treated by major component sections, it can be readily repaired in the field. With a major component, such as the Pulse Voltmeter, the UHF Unit, the VHF Unit, etc. removed from the cabinet, parts are easily accessible for maintenance and replacement. Refer to Figure 46 for major component breakdown and interconnecting cables. All tubes, with the exception of those used in the Signal Generator (UHF Unit and VHF Unit), may be replaced after simple removal of the dust cover of the instrument. The RF tubes, with the exception of three UHF triodes, are available after removal of the RF Unit cover. The three UHF triodes require special disassembly procedures and precautions.

## PREVENTATIVE MAINTENANCE

### Conserving Tube Life

CAUTION: If the 235A is to be left operating for short periods of time (an hour or two), it is recommended that it be left in the PULSE position. For longer periods of time (several days), it is recommended that it be left in the CW position, with the RF level control turned fully counterclockwise (RF off). In the interest of conserving tube life, the instrument should never be operated over red line.

### Lubrication

The 235A is adequately lubricated for the life of the instrument. The primary area of lubrication is on the cams used to drive the piston capacitors in the UHF Unit. The only reason for added lubrication would be in the case of disassembly where the original lubrication might have been wiped off.

The lubricant used in the cam assembly is Molycote "G". It is manufactured by Alpha Molycote Corporation, Stamford, Connecticut and should be applied sparingly—a uniform thin film being best.

## TROUBLE SHOOTING AND REPAIR

### Tube Replacement Guide

The Tube Replacement Guide is primarily a check list to show the tube functions and readjustments that might be required after tubes are changed. The "Symptoms Noted" information, like the Trouble Shooting Chart, is included as an organized starting point in the event that the instrument is not performing properly.

To gain access to the tubes, the following disassembly procedures must be used:

1. Removal of the dust cover of the instrument will allow changing of the following tubes: V400, V401, V402, V403, V404, V405, V600, V601, and V602.
2. Removal of the dust cover of the instrument and the RF Unit cover (See Disassembly Procedure) will allow changing of the following tubes: V100, V101, V102, V103, V104, V203, V204 and V205. For ease of replacement of these tubes the VHF Unit should be removed (See Disassembly Procedure).
3. Removal of the dust cover of the instrument, the RF Unit cover, and two bottom plates of the UHF Unit will allow changing of the following tubes: V200, V201, and V202.

CAUTION: These tubes require special precautions. See disassembly procedures before attempting replacement.

### TUBE REPLACEMENT GUIDE

| Tube Ref. Symbol | Tube Type | Application | Readjustment Required | Symptoms Noted |
|---|---|---|---|---|
| V100 | 5670 | Tens Oscillator | VHF Alignment check | Weak or no output from the Signal Generator |
| V101 | 6AS6 | Mixer | VHF Alignment check | Weak or no output from the Signal Generator |
| V102 | 6AK5 | Amplifier | VHF Alignment check | Weak or no output from the Signal Generator |
| V103 | 6AH6 | Buffer | VHF Alignment check | Weak or no output from the Signal Generator |
| V104 | 5670 | Units Oscillator | VHF Alignment check | Weak or no output from the Signal Generator |
| V200 | 5876 | Mixer | UHF Alignment check | Weak or no output from the Signal Generator |
| V201 | 5876 | Amplifier | UHF Alignment check | Weak or no output from the Signal Generator (See Service Note) |
| V202 | GL-6299 | Doubler- Output | UHF Alignment check | Weak or no output from the Signal Generator |
| V203 | 5670 | Oscillator-Doubler | UHF Alignment check | Weak or no output from the Signal Generator (See Service Note) |
| V204 | 6AK5 | Tripler | UHF Alignment check | Weak or no output from the Signal Generator |
| V205 | 6AN4 | Doubler | UHF Alignment check | Weak or no output from the Signal Generator |
| V400 | 6AU8 | Amplifier—Phase Inverter | None | No meter indication With defective Phase Inv only there will be weak indication in CAL position |
| V401 | 5687 | Dual Cathode Follower | None | Defective V401A—No indication on meter Defective V401B—No indication from XMTR DEMOD. |

| Tube Ref. Symbol | Tube Type | Application | Readjustment Required | Symptoms Noted |
|---|---|---|---|---|
| V402 | 6AL5 | Slide Back Diode | Check Pulse Sens Adj | No meter indication |
| V403 | 12AT7 | Amplifier | None | No meter indication |
| V404 | 6AL5 | Detector | None | No meter indication |
| V405 | 12AX7 | Amp—Cathode Follower | None | No meter indication |
| V600 | 6AU6 | Volt Reg. Amp | Check B + ADJ | Poor regulation |
| V601 | 6080 | Series Volt Reg. | Check B + ADJ | 235A Inoperative or poor regulation |
| V602 | 5651 | Volt Reference | Check B + ADJ | Poor regulation |

### Trouble Shooting Chart

The Trouble Shooting Chart lists symptoms that could possibly develop in the instrument and details faults, probable causes of these faults, remedies, and procedures for correcting these conditions. It is suggested that this chart be used as a first step in analyzing trouble since considerable time and effort associated with unnecessary readjustment or alignment can therefore be avoided.

## TROUBLE SHOOTING CHART

| SYMPTOM | PROBABLE CAUSE | LOCALIZING AND REMEDYING FAULT |
|---|---|---|
| 1. No Panel Meter reading at all frequencies on each band. Connect a power meter to front panel RF connector and turn RF control clockwise and Attenuator control to −10 dbm. | | |
| A. Power meter indicates power. | Defective meter circuit. | Using a 20,000 ohm per volt DCVM, check for variation of voltage at junction of R501 and R502 on meter board with change in RF control setting. If no change, fault is in metering circuitry within RF Unit, thermistors, RF filter, cabling, or connections 5 and 6 in J518 and P518. If change is indicated, fault is on meter terminal board and/or indexing of S400B. |
| B. Power meter indicates no power or low power. | Defective UHF oscillator string. | Measure output at P200 with RF VTVM. If no output is indicated, fault is due to failure of B+, heater, V203, V204, V205, and/or associated components. See Voltage and Resistance Chart. |
| | Defective VHF Unit | Measure output at P201 with RF VTVM. If no output is indicated, fault is due to failure of B+, heater, V100, V101, V102, V103, V104, and/or associated circuitry. See Voltage and Resistance Chart. |
| | Defective UHF output string. | Connect 20,000 ohm per volt DCVM to C209 and turn RF control clockwise. If bias increases, fault is with V202 stage or piston attenuator. Repeat with DCVM connected to junction of R209 and R221 on diode plate. If voltage becomes more negative, fault is with attenuator or coupling to attenuator. Check attenuator continuity by measuring into P500 a PWR MEAS detector with NORMAL-PWR MEAS switch in PWR MEAS position. If voltage at diode does not follow RF control, fault is with V202 stage. If bias at C209 does not follow RF control, repeat procdure measuring bias of V201 at TP202. If bias varies with RF control, fault is with V201 stage. If bias does not vary with RF control fault is with V200 stage. See Voltage and Resistance Chart and Tube Replacement Guide. If realignment is necessary, refer to UHF Unit Alignment Procedure. Retracking can be accomplished without disassembly of the UHF Unit or other assemblies. |

| SYMPTOM | PROBABLE CAUSE | LOCALIZING AND REMEDYING FAULT |
|---|---|---|
| 2. No RF output or low RF output on high band. | UHF oscillator string failure. | Using a 20,000 ohm per volt DCVM, measure voltage at TP201. If reading is approximately 3 volts, fault is with V205 stage. If indication is less than 3 volts, measure at TP200. If reading is approximately 0.8 volt, fault is with V204 stage. If indication is less than 0.8 volt, fault is with V203 stage. See Voltage and Resistance Chart. Remove bottom cover to check operation of S200A. Switch contacts must open on high band. Check operation of S200B with ohmeter. If adjustment of peaking controls is necessary (except for C235, which is available through the back RF plate), it will be necessary to remove the VHF Unit. See procedures for removing VHF Unit and tuning UHF oscillator. |
| 3. No RF output or low RF output on low band. | UHF oscillator string failure. | Same as for Symptom 2 except that S200A switch contacts must be closed on low band. C236 is accessible through back plate. |
| 4. No RF output or low RF output on one Tens switch position for any Units switch position on both bands. | VHF Unit failure. | Tens oscillator failure or misalignment of particular channel in succeeding stages. Alignment of upper five Tens channels can be performed without removing VHF Unit. Remove cover of unit to make voltage and resistance measurements. Remove VHF Unit to align lower four Tens channels. See procedures for removing and aligning the VHF Unit. |
| 5. No RF output or low RF output on one Units switch position for any Tens switch position on both bands. | VHF Unit failure. | Failure of crystal or misalignment of particular channel associated with C123 through C132 and C149 through C158. Unit may be realigned without being removed. See VHF Unit alignment procedure. |
| 6. Excessive pulse overshoot. | Faulty UHF tracking. | Usually occurs only on higher channels of high band. Check tuning of V201 high band cam by pushing up and down on cam follower. Loosen cam and slip on shaft in direction to reduce overshoot. Detent Tens switch several times to insure proper seating of cam follower, then recheck overshoot. Check that CW level on high band is sufficient; i.e., reserve output of 3 db or more. |
| 7. Excessive spurious frequencies appearing as beat note on top of oscilloscope pulse display. | | |
| A. Appears on one band only. | UHF oscillator string not properly aligned. | Check tuning of C235 or C236, accessible through back plate. If capacitor is properly tuned, it will be necessary to remove the VHF Unit and realign the UHF oscillator string. See procedures for removal of VHF Unit and alignment of UHF oscillator. |
| B. Appears on corresponding channels on both bands. | VHF Unit not properly aligned. | See Symptoms 4 and 5 above and refer to procedures for removal and alignment of the VHF Unit. |
| 8. Excessive hum on top of pulse and base line of CRO display. Appears on all channels. | Heater—cathode leakage in V400 in Pulse Voltmeter Unit. | Replace tube. |
| 9. Distorted pulse top. Appears on all channels as decaying wave on pulse top. | Faulty modulation by-pass capacitor C237, located below MOD LEVEL control in RF Unit. | Replace capacitor. |
| 10. No internal pulse or low internal pulse at MONITOR OUTPUT connector with Function Selector Switch in CAL or PULSE position and NORMAL-PWR MEAS switch in NORMAL position. Set NORMAL-PWR MEAS switch to PWR MEAS, Attenuator Control to —10 dbm, and Function Selector Switch to PWR MEAS. | | |

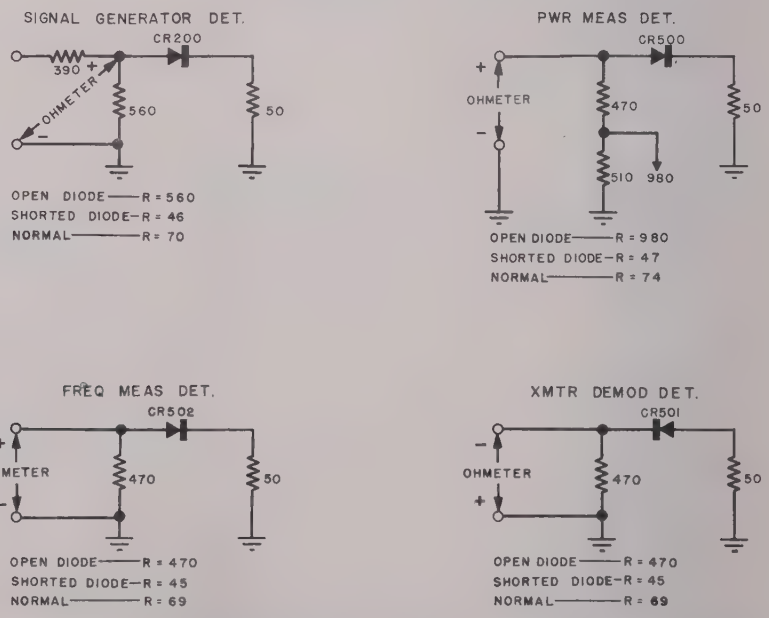
| SYMPTOM | PROBABLE CAUSE | LOCALIZING AND REMEDYING FAULT |
|---|---|---|
| A. Pulse appears. | Faulty Signal Generator Detector CR200 or associated wiring. | Switch Function Selector Switch to PULSE and NORMAL-PWR MEAS switch to NORMAL. Connect oscilloscope to output of P402 on Pulse Voltmeter. If pulse appears, fault is with J402 and P402 connection, indexing of S400A in Pulse Voltmeter, or wiring to S400A. Remove Pulse Voltmeter Unit and check these points. If no pulse appears at P402, fault is in RF Unit. Check with oscilloscope for pulse at junction of R218 and R209 at Signal Generator detector. If pulse is detected, fault is with R209, coax cable, or RF Filter No. 2. Check continuity from P402 to R218. If no pulse is detected at junction of R118 and R209, measure dc resistance from junction to ground. If resistance is about 45 ohms, CR200 is shorted. If resistance is about 560 ohms, CR200 is open or connection between CR200 and R208 is open. Check diode. If not open, remove cover plate over V202 stage and check connection to R208 and between R208 and ground. |
| B. No pulse appears. | Fault at Pulse Voltmeter or front panel. | Connect oscilloscope to P401. If pulse is detected, fault is with alignment of S400A, V400A, V401A, or associated circuitry in the Pulse Voltmeter Unit. In no pulse is detected at P401, check with oscilloscope for presence of modulation signal at S400B on front panel. |
| 11. No pulse or low pulse at MONITOR OUTPUT connector with Function Selector Switch in PULSE only. Pulse present in CAL position with NORMAL-PWR MEAS switch in NORMAL position. | No Modulation from RF Unit. | Check for presence of modulation at C212 in RF Unit. If modulation is not detected, trace back through MOD LEVEL control R220 and RF Filter No. 2 to switch S400B. If modulation is detected at C212, remove bottom plate on UHF Unit, exposing V200 and V201, and check with ohmmeter for shorted C211, V202 grid capacitor. If C211 is not shorted, check effect of varying the high bias control (R407) in the Power Supply. If no effect on reading is noted, check Zener diode CR604 in Power Supply. |
| 12. No internal pulse or low internal pulse at MONITOR OUTPUT connector with Function Selector Switch in CAL or PULSE position, NORMAL-PWR MEAS switch in PWR MEAS, and Attenuator control set to −10 dbm.<br>Switch Function Selector Switch to PULSE and NORMAL-PWR MEAS switch to NORMAL. | | |
| A. No pulse appears. | See Symptom 10B above. | |
| B. Pulse appears. | Fault in PWR MEAS detector (A501) or associated wiring. | Switch NORMAL-PWR MEAS switch to PWR MEAS and Function Selector Switch to PWR MEAS. Connect oscilloscope to output of PWR MEAS detector, R515, to ground. If pulse is detected, fault is in cable from detector to Pulse Voltmeter, J401 and P401 connection, or indexing of S400A in Pulse Voltmeter. If no pulse is detected, switch Function Selector Switch to CW and adjust level to red line. Using power meter at P500, measure input to PWR MEAS detector. Level should be 0 dbm. If level is 0 dbm, detector is defective; check diode. If no signal is detected, fault is in cable to detector or NORMAL-PWR MEAS switch. |
| 13. No pulse or low pulse at XMTR DEMOD detector (A502) with transmitter firing into 235A.<br>Connect oscilloscope to detector output, across R516. | | |
| A. Pulse is detected. | Defective cable to Pulse Voltmeter. | Repair cable. |
| | Faulty J407, P407 connection. | Repair connection. |
| | Fault in V401B stage in Pulse Voltmeter. | Replace defective component. |
| | Faulty J406, P406 connection. | Repair connection. |
| | Defective cable from Pulse Voltmeter to front panel. | Repair cable. |

| SYMPTOM | PROBABLE CAUSE | LOCALIZING AND REMEDYING FAULT |
|---|---|---|
| B. No pulse is detected. | Defective XMTR DEMOD detector and/or output cable.<br>Defective Dual Coupler (AT503) or cable from coupler to detector. | If no pulse is detected, remove input cable to detector and connect to FREQ MEAS detector. Connect oscilloscope to output of FREQ MEAS detector, across R517. If Pulse (reverse polarity) is detected, XMTR DEMOD detector and/or output cable is defective. If no pulse is detected, dual coupler or cable from coupler to detector is defective. |
| 14. No pulse or low pulse at MONITOR OUTPUT connector with transmitter firing into 235A; Function Selector Switch in FREQ MEAS position.<br>Connect oscilloscope to FREQ MEAS detector (A503) output, across R517. | | |
| A. Pulse is detected. | Defective cable to Pulse Voltmeter. | Repair cable. |
| | Faulty J400, P400 connection. | Repair connection. |
| | Faulty indexing of S400A. | Adjust indexing of switch. |
| B. No pulse detected. | | Interchange with XMTR DEMOD detector and proceed as for Symptom 13 above. |
| 15. Panel Meter will not reach CAL level when pulse is adjusted with MOD LEVEL control. | Incorrect setting of low bias control, R606, in Power Supply. | Adjust control and check Pulse—CW ratio. |
| | Defective output tube, V202. | Replace tube. |
| 16. With Function Selector Switch set to CW, RF level increases and then decreases as RF control is turned clockwise. | See Symptom 15 above. | |

NOTES

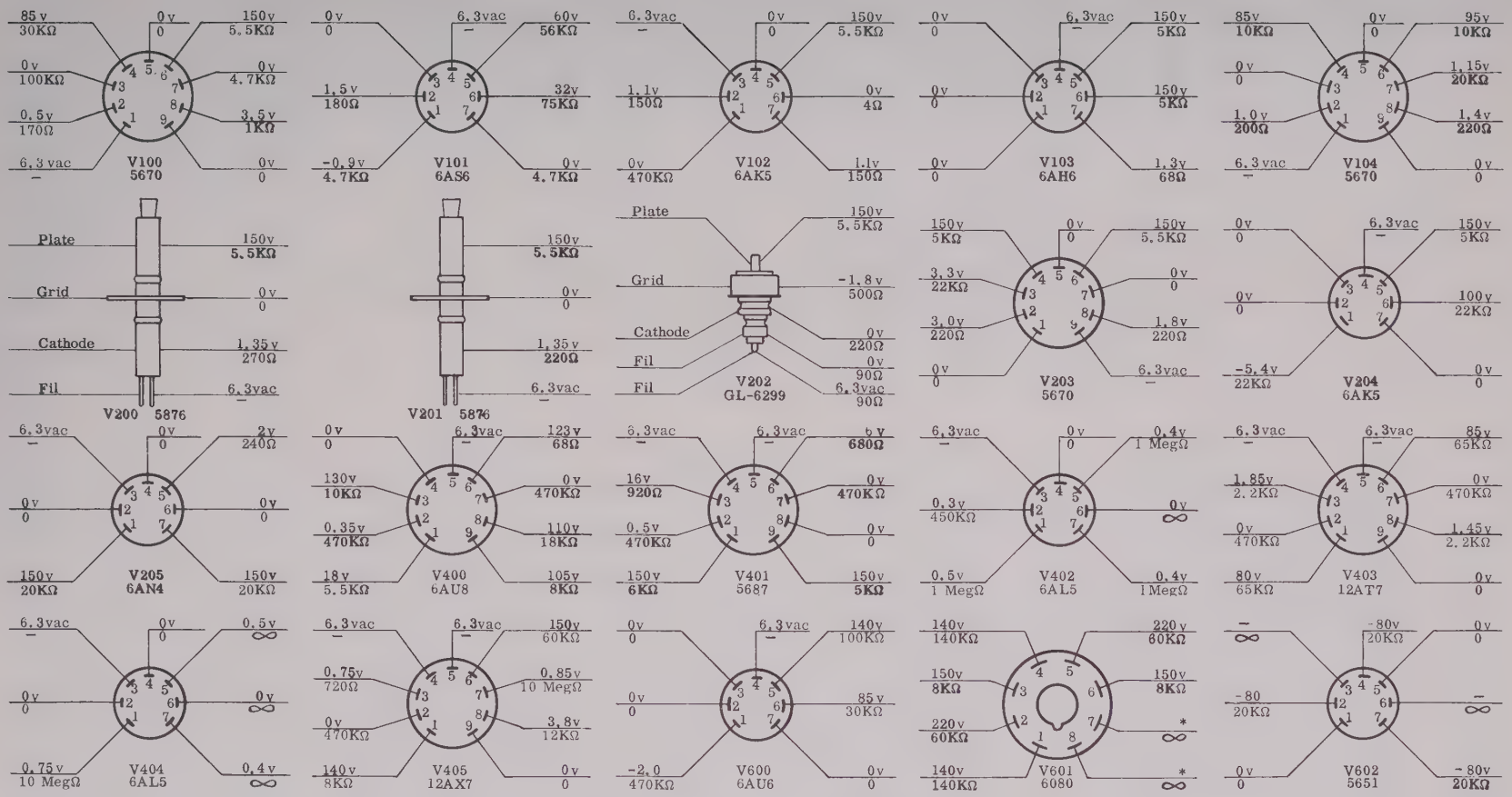
1. Polarity of ohmmeter leads will effect reading.
2. All readings taken with cables removed (except CR200).
3. Resistance values are approximate.

DIODE RESISTANCE CHECK




## Voltage and Resistance Chart

The Voltage and Resistance Chart shows normal operating conditions for the 235A with no external equipment attached; viz., DME Radio Set, ATC Transponder, or Modulators. Voltages were checked with a 20,000 ohms per volt meter. Resistance readings were made under the same conditions with the power disconnected. Some resistance readings were omitted as the readings have no significance; i.e., cases where electrolytic capacitors or semiconductor devices are connected in the circuit.




## VOLTAGE AND RESISTANCE CHART

## MECHANICAL DISASSEMBLY PROCEDURES

NOTE: In the process of disassembly or alignment, some screws will be found to be exceptionally tight. These screws are sealed at the factory. One type of seal (BLUE in color) is Glyptal and is easily broken. A second type of seal, used in other applications, cannot be broken by force alone. With sufficient force and without special processing, the screw could be broken. This seal (RED in color) is a "liquid locknut" and must be softened with heat before removal. A 250 watt soldering iron may be used for this purpose.

### RF Unit Cover

The RF Unit cover is held in place with a total of eighteen screws. Place instrument on front panel handles for disassembly. To remove this cover, the support bracket at the back of the RF Unit must be taken off. The bracket is secured to the bottom of the 235A and is fastened through the cover by two screws. Next, the six screws around the Piston Attenuator are removed. By removal of the ten screws at the front end of the RF Unit, the cover will be free to slide off of the RF Unit. (A screwdriver with a 12 inch blade will facilitate removal of the cover.) With the cover removed, it is recommended that the rear support bracket be reinstalled to hold the RF Unit solidly in place.

### VHF Unit

After taking off the RF Unit cover, the VHF Unit may be disassembled from the 235A. Four screws mount the VHF Unit in place. After removing the screws, the unit is slid rearward to disengage the flexible couplings. It should be noted that the Delrin center pieces of the couplings are loose parts and care should be taken not to lose them.

CAUTION: The original relationship of the front panel knobs to the switch shafts must be maintained when re-assembling the VHF Unit or the dial calibration (CH and MC) will be incorrect.

The BNC connector (P100) must be disconnected. To completely remove the VHF Unit, five wires must be unsoldered from terminals on the tube side of the VHF chassis. Normally there is enough slack in the wires to allow repair work without removing these wires.

### UHF Unit

CAUTION: Extreme care should be exercised to avoid damaging the glass piston capacitors (C203, C208, and C215) operated by the cams. Special equipment is required in their replacement and the procedure cannot be readily performed in the field.

There is no need to remove the UHF Unit. After moving the VHF Unit out of the way, all repairs can be accomplished on the UHF Unit; either from the top or through the bottom, after removal of the bottom covers.

### RF Filters

The RF filters can be removed from the instrument after the VHF Unit is moved out of the way. The filters must be unsoldereed at the Input end which attaches to the UHF or VHF Units. For partial removal of the filters, the yellow wire between Filter No. 1 and the plug (P518) must be cut. (This wire can be spliced when filters are replaced.) The large hex nut is taken off. The filters will then slide out of position for checking or repairs. For complete removal, the plugs (P518 and P602) must be removed. The covers will slide off to make the components available.

### Pulse Voltmeter

The pulse voltmeter chassis can be completely removed from the 235A using the following procedure:

1. Remove eight screws securing the voltmeter chassis to top of power supply.
2. Turn Function Selector Switch to FREQ MEAS. (When replacing the voltmeter, setting the control switch shaft to this full clockwise position will align S400A and S400B properly.) Loosen the two setscrews at end of flexible shaft.
3. Disconnect the six color-coded connectors (P400, P401, P402, P405, P406, and P407).
4. Carefully lift the voltmeter chassis and disconnect plug (P603) which is located under the chassis.

For ease in replacing components, the side panels are removable from the pulse voltmeter chassis, except in a few limited cases. When reassembling, check alignment of switch electrically; i. e., pulse modulate the 235A and be sure that meter reads in CW, CAL, PULSE, and PWR MEAS positions.

### Precision Attenuator

The precision attenuator may be completely removed from the 235A using the following procedure:

1. Remove both side brackets from the 235A. These brackets are secured to the front panel and bottom of the 235A.

2. Remove two screws through bottom of 235A which secure the precision attenuator bracket. (In some cases there are nuts which must be held in place during disassembly.)
3. Remove four screws through front panel which secure the RF jack (J516).
4. Disconnect the four connectors (P505, P508, P512, and P515), and carefully slide the attenuator out of place toward the right side of the instrument.

### Piston Attenuator

The Piston Attenuator may be completely removed from the 235A using the following procedure:

1. Remove RF Unit cover (See Disassembly).
2. Remove side panel and bottom cover screws from front panel.
3. Tip 235A up on front panel handles.
4. Disconnect plugs P402, P405, and P406 from pulse voltmeter, and P500, P501, and P502 from detector blocks.
5. Disconnect flexible shaft between S400A and S400B (pulse voltmeter to front panel).
6. Remove right side panel from bottom cover.
7. Remove screws which retain the precision attenuator and piston attenuator support brackets to bottom cover.
8. Lift off assembly consisting of the power supply, pulse voltmeter, left side panel, and bottom cover, while disconnecting the two power supply plugs (P601, P602).
9. Remove front panel Attenuator Control knob.
10. Loosen setscrews in all collars and gears on the attenuator control shaft, except the stop collar at the extreme end. Remove retaining ring next to attenuator dial and slide shaft toward rear of 235A in order to clear the front panel.
11. Remove smallest bottom cover from the UHF Unit to unsolder coil fastened to the hairpin at the end of attenuator tube.
12. Remove four retaining screws securing attenuator to UHF Unit.
13. *Carefully* slide attenuator out of UHF Unit. (Do not tilt attenuator, as the close tolerances at UHF Unit will cause it to bind in the hole.)
14. When reinstalling the piston attenuator the process can be reversed. After installation, the output stage tracking and the RF monitor meter calibration must be checked and adjusted if necessary.

### Wavemeter

The wavemeter can be completely disassembled from the 235A by removing the knob and four front panel screws, and disconnecting the two BNC plugs (P502 and P504).

### Meter Movement

The meter movement may be removed from the 235A by using the following procedure:

1. Remove three knobs; ZERO, RF, and Function Selector Switch.
2. Remove the three hex nuts from the above control shafts.
3. Remove two hex nuts from meter terminals which secure the terminal board.
4. Tilt back terminal board.
5. Remove four hex nuts to disengage the terminal connections to the meter.
6. Remove hex nuts from each corner of the meter movement and slide meter through the front panel of the 235A.

### Band and Cable Replacement

The Frequency Selector Knobs utilize band and cable drives in the gear assembly. Figs. 8 and 9 show the physical configuration for each band and cable as per the conditions described with each. After changing bands or cables, check to assure the front panel calibration and channel indication are correct.

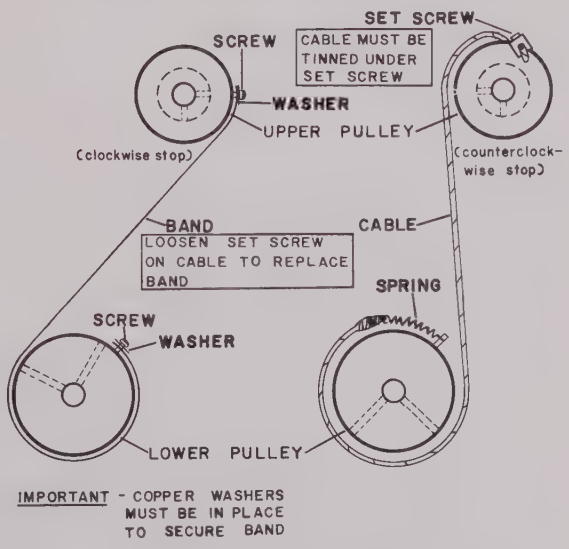



*Figure 18. Band and Cable Replacement—Front Pulleys*

### Tube and Semiconductor Replacement

#### *Tube Type 5876*

This pencil triode has a glass portion at either side of the center. Therefore, special precautions must be taken during removal and replacement to avoid breaking the glass.

Remove filament socket, gently, so as not to disturb the wiring. Using the double hook tool as shown in Fig. 20, lift both ends of the tube out of the clips at the same time. Tilt tube slightly when out of the

clips to clear edge of chassis. Retracking of the stage involved will possibly be necessary.

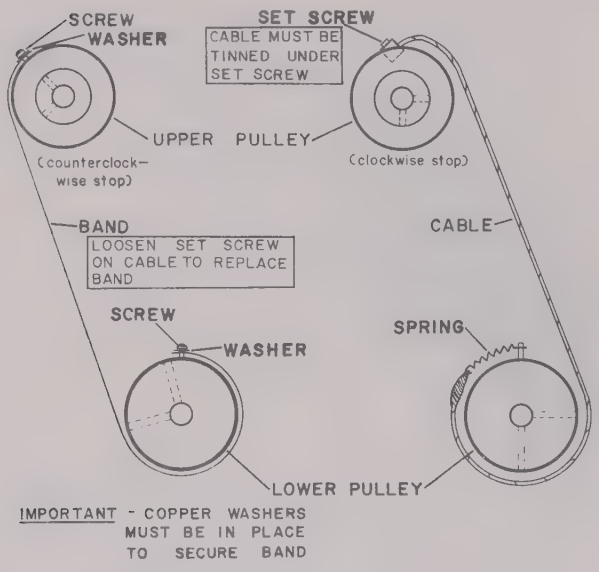



*Figure 19. Band and Cable Replacement—Rear Pulleys*

*Tube Type GL-6299*

This tube may be easily replaced by sliding the grid plate in which it is mounted toward the side of the chassis until the tube clears the clips. Lift out carefully to avoid disturbing the position of wires and components. Retracking will possibly be necessary (See Alignment Procedure).

*CR200 (MA424 or MA425) (Sig. Gen Det)*

This diode, in the UHF Unit, is held in place with a No. 2 socket head setscrew. It can be removed from the top of the chassis by loosening the setscrew and lifting up.

*CR500 (MA424 or MA425) (Pwr Meas Det)*

This diode may be removed from the 235A by taking off the cover of the detector block, A500.

CAUTION: MA425 diodes are reversible; when reinstalling diodes make sure (+) or (•) is toward the bottom of the block.

*CR501 (MA425) (XMTR Demod Det)*

This diode may be removed from the 235A by taking off the cover of the detector block, A501.

CAUTION: Diodes are reversible. When reinstalling this diode, make sure (+) or (•) is toward the top of the block. See Service Note.

*CR502 (MA424 or MA425) (Freq Meas Det)*

This diode may be removed from the 235A by loosening the setscrew in the top of the detector block and lifting out the diode.

CAUTION: If MA425 diode is used as a replacement be sure (+) or (•) is toward the bottom of the block.

**Crystal Replacement**

*Y200 and Y201*

Y200 and Y201 crystals are the plug-in type and are readily accessible on the top of the UHF Unit.

*Y100 to Y118 (inclusive)*

These crystals are soldered into the VHF Unit. When replacing crystals, use a small, low-temperature soldering iron. Hold wires between crystal and solder connection with long nose pliers to dissipate the heat and prevent damage to the crystal.

## ADJUSTMENT AND CALIBRATION

**Power Supply (B+ Adj)**

Connect a 1% DC Voltmeter to the junction of R615 (33 ohms) and R616 (33 ohms) on power supply and chassis ground. Adjust R617 (B + Adj) for 150 volts dc with an input voltage to the 235A of 115 volts ac (or 230 volts ac).

1. Filament voltage should read 6.3 volts ac ±5%.
2. B + ripple should be less than 0.003 volts.
3. B + regulation should not exceed ±0.5 volts over the range of 105 to 125 volts ac input to the 235A (or 210 to 250 volts ac input).

**Bias Control Adjustment**

*Equipment Required*

1. GR Unit Oscillator (900—2000 mc), MR Detector, and IF Amplifier
2. Collins 578X1 Modulator

The following bias adjustment is made at 1030 mc with the Function Selector in CW position.

1. Set LOW BIAS (R606) and HIGH BIAS (R607) to minimum (fully counterclockwise).
2. Set RF level for red line on RF MONITOR meter with the attenuator set for —10 dbm and observe output on IF Amplifier. (GR Unit Oscillator is beat with 235A output to give peak

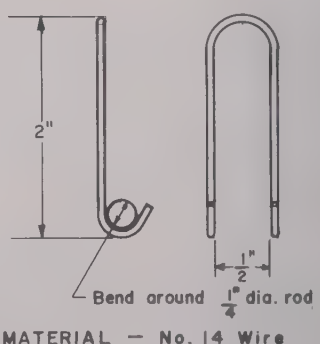



*Figure 20. Tool—Tube Puller*

indication on GR IF Amplifier.)

3. With Function Selector in the PULSE position (no modulation input), adjust HIGH BIAS (R607) clockwise until signal on IF Amplifier is at least 60 db down.
4. Connect the Collins 578X1 Modulator to MOD IN jack on the front panel of the 235A. With Function Selector switch in the CAL position, observe reading.
5. Switch Function Selector to PULSE position and increase MOD LEVEL until saturation is reached. Saturation is reached when RF MONITOR meter goes through a maximum indication. This should occur no less than 5% above the CAL level, as observed in (4).
6. If saturation level is below that specified in (5), set MOD LEVEL control to saturation and RF level control to 5% above CAL, as observed in (4).
7. Switch Function Selector to CW and adjust LOW BIAS (R606) for red line output on RF MONITOR meter.
8. PULSE—CW ratio may have changed so that steps (2) through (7) should be repeated until proper PULSE—CW ratio as specified in (5) is reached.

**VHF Unit Alignment Procedure:**

The following alignment procedure is for a complete factory-type alignment of a new instrument. For normal field repair or "touch-up" alignment, repair time can usually be minimized by referring to the Trouble Shooting Chart.

***Equipment Required***

1. HP VTVM Model 410B or equivalent
2. HP T-probe Detector Model 455A or equivalent
3. 50-ohm Termination
4. Tools
   a. Non-metallic screwdriver
   b. Screwdriver blade alignment tool

***Preliminary Set-up and Adjustment***

*Mechanical*

CAUTION: Do not loosen switch wafers on VHF Unit as alignment of these wafers is very critical.

Remove the top cover of the VHF Unit. All alignment is performed with this cover off. Disassemble the VHF Unit (See Disassembly Procedure) from the instrument and disconnect the output plug (P100). Balance of wires should remain connected. Move unit into position shown in Fig. 21. Temporarily extend

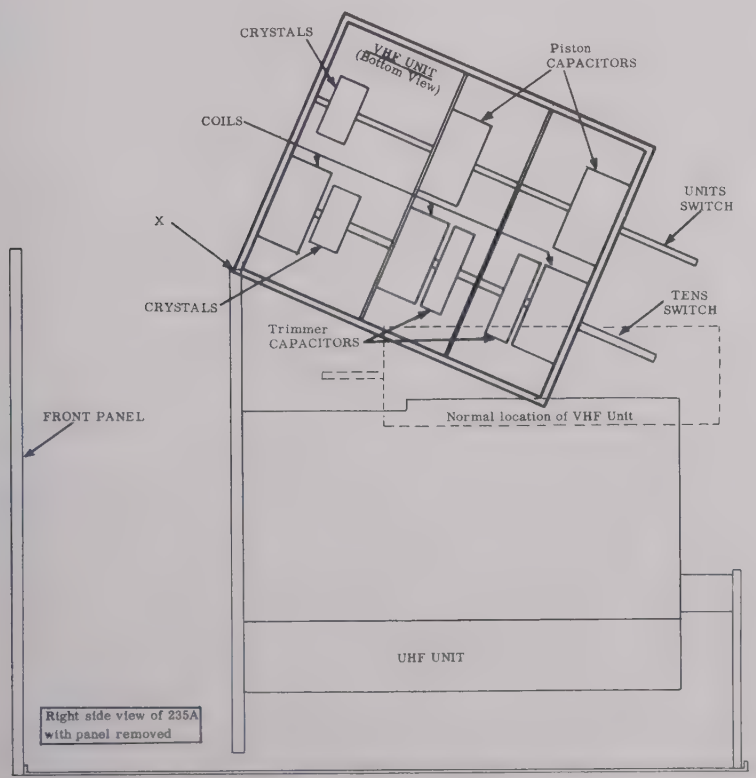



***Figure 21. Alignment Position—VHF Unit***

wires if required. A small C-clamp at location "X" will hold unit in place during alignment procedure.

Preset, mechanically, piston capacitors (C123 to C132 inclusive and C149 to C158 inclusive) by setting the low end capacitors (C123 and C149) 1-1/2 turns from the full mesh position. Next, set high end capacitors (C132 and C149) 1-1/2 turns into mesh. This can be done visually. The eight remaining capacitors in each section should be set in equal increments between these positions such that the capacitance of each is increasingly less from the low end to the high end of the frequency range.

*Electrical*

Apply power to 235A. Connect the HP 410B to pin No. 7 of V101 (6AS6). Check Unit Switch (S101) in all positions. Minimum RF output should be no less than 0.9 volts.

Connect the HP 410B to pin No. 1 of V101 (6AS6). Check Tens Switch (S100) in each position, while peaking coils L106 through L114. Adjust coils so that output is approximately 5% down on the slow tuning side of the peak. Minimum ac output should be no less than 0.3 volts.

With the HP 410B use the HP 455A Probe and a 50-ohm termination to connect to the output jack (J100) of the VHF Unit.

Mechanically set the trimmer capacitors (C113 to C121 inclusive and C139 to C147 inclusive) to one turn back from maximum capacitance.

***Alignment***

With the Units Switch (S101) in the No. 1 position (first position next to wiper contact on switch), and the Tens Switch (S100) in the full counterclockwise position, adjust trimmer capacitors C113 and C139 for peak. Turn Units Switch (S101) to the No. 10 position. Adjust L124 and L134A for maximum output. Repeat trimmer adjustment with Units Switch in the No. 1 position. Repeat coil adjustment with the Units Switch in the No. 10 position.

When it is assured that C113—C139 and L124—L134A can be peaked for Units switch positions No. 1 and No. 10, repeat the procedure, operating between Units switch positions No. 2 and No. 9. Adjust C113 and C139 at position No. 2, and L124 and L134A at position 9, repeating until maximum output is obtained at both Units switch positions.

With the Tens switch in the full counterclockwise position, adjust all of the piston capacitors associated with the Units switch for maximum output in each position of the Units switch, excepting positions No. 2 and No. 9.

Turn the Tens Switch one position in the clockwise direction. Following the same procedure, switch the Units Switch from No. 2 to No. 9 adjusting the trimmers and coils associated with the Tens Switch. This second step involves the adjustment of C114 and C140 with the Units Switch in the No. 2 position and the adjustment of L123 and L133A in the No. 9 position.

Using the same system, adjust the balance of the trimmer capacitors C115 to C121 inclusive and C141 to C147 inclusive. Also, adjust the balance of the coils L122 to L116 inclusive and L132A to L126A inclusive. In each series of adjustments, repeat the steps in the No. 2 and No. 9 positions until no further adjustment is necessary.

Set the Units Switch and the Tens Switch to the full counterclockwise position. The output voltage should be approximately 0.9 volts. This is the reference level. Set the Tens Switch to the fifth position CW. Adjust the coupling loop (L130B) of the output coil (L130A) for about the same output as the reference level.

Repeat the output coil adjustment to the reference level for the sixth to ninth positions (L129B to L126B inclusive).

Reassemble the VHF Unit to its proper position on the 235A. Replace the top cover and reconnect the output plug (P100). (If complete UHF Unit alignment is to be done, do not replace the VHF Unit.)

**UHF Unit Alignment Procedure**

The following alignment procedure is for a complete factory-type alignment of a new instrument. For normal field repair or "touch-up" alignment, repair time can usually be minimized by referring to the Trouble Shooting Chart.

***Equipment Required***

1. HP VTVM Model 410B or equivalent
2. 20,000 ohms per volt meter
3. HP T-probe Detector Model 455A or equivalent
4. HP Power Meter 431A
5. HP Thermistor Mount 478A
6. 50-ohm termination
7. Tools
   a. Screwdriver (6" lg. x 1/8" dia. blade)
   b. Short screwdriver blade alignment tool (approx. 2" lg.)
   c. Socket head setscrew wrench (No. 10)
   d. Socket head setscrew wrench (No. 2)
   e. Fuse puller, composition (for diameters 1/4" to 1/2")
   f. Special tool for adjusting cam followers (See Fig. 22 for details.)

***Preliminary Set-up and Adjustment***

For alignment of circuitry associated with V203, V204, and V205, the VHF Unit must be out of the way. (See VHF Disassembly Procedure.)

Pre-set tuning slugs in the coils (L214 and L215) for five turns in from minimum inductance.

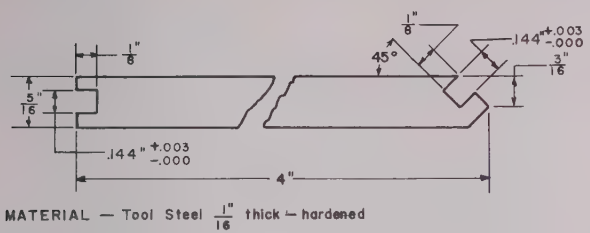



*Figure 22. Tool—Cam Follower Alignment*

### *Alignment*

1. Apply power to 235A and connect the 20,000 ohms per volt meter to TP200. Turn bandswitch to the 1130-1219 mc band. Adjust C219 and C224 for maximum voltage of approximately —0.8 volts. Set C219 so that the output is down about 5% on the slow tuning side of the crystal tuning characteristics.
2. Change meter connection to TP201. Adjust C230 for a maximum voltage of approximately 3 volts.
3. Connect the HP 410B using the HP 455A Probe and 50-ohm termination to jack (J202). Adjust C235 for maximum of not less than 1.0 volt ac.
4. Change bandswitch to the 960-1049 band. Following the procedures of 1, 2, and 3, adjust C218, C225, C231, and C236.
5. Check output in both positions of the bandswitch. Voltages should not be less than 1.0 volt and should be within approximately 15% of each other.

Using a frequency counter the output frequencies should be: 533.90 mc ±12.3 kc for the high band; and 448.90 mc ±11.2 kc for the low band.

### *Cam Tracking (See Fig. 23)*

*Preliminary Adjustment*

Check the cam follower blocks for the following:

1. Cam follower blocks must be straight and tight.
2. There must be equal spring tension on the cam blocks at either extreme of piston travel. (To adjust the springs (Fig. 45 Part No. 307-634) the collars at the end of the springs must be rotated on the shaft. DO NOT bend springs to change tension as spring leaf might break. Replacement of a broken spring would entail replacement of the collar and the preformance of an involved adjustment procedure.)
3. With the 235A set to 1049 or 1219 mc, the engraved marks on the cams should line up with the front edge of the cam follower blocks.
4. The cams must not bind on the cam follower blocks through the entire piston travel.
5. Reassemble the VHF Unit in its proper position. Check the output of the unit using the 410B and "T" probe to insure proper indexing of the switches as the front panel Tens and Units controls are operated through all their positions.

Preset the three capacitors (C201, C206, and C213) to three turns in from minimum capacitance.

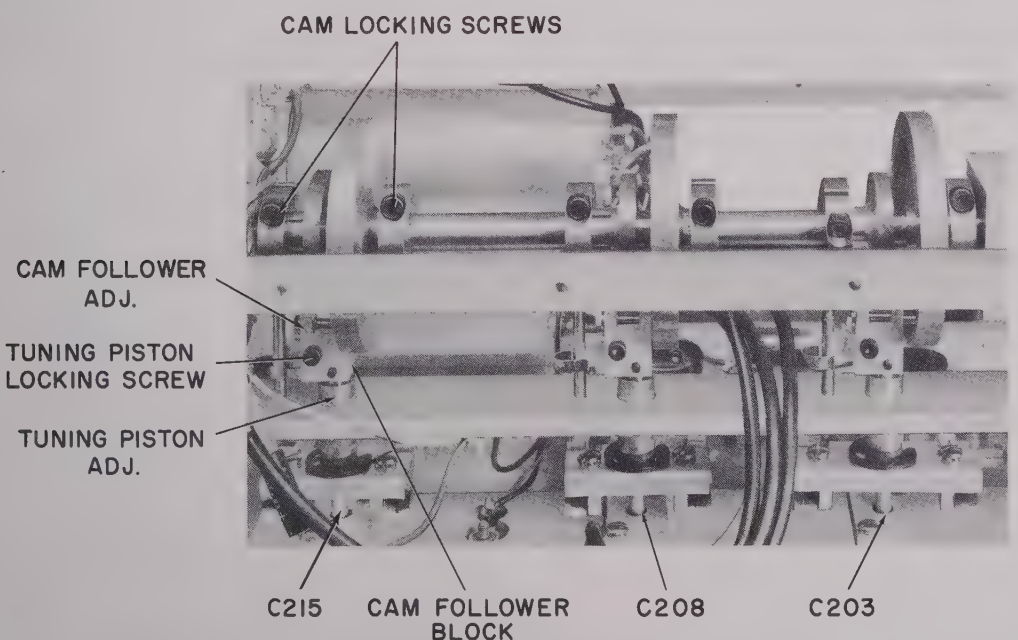



*Figure 23. UHF Cam Alignment*

*Alignment and Tracking (Fig. 23)*

Apply power to the 235A. Turn the RF level control clockwise, function switch to CW, and coax switch to NORMAL. Connect 20,000 ohms per volt meter to TP202; HP 431A and 478A to the RF output jack (J516). Set 235A frequency at 1219 mc. Loosen C203 tuning piston locking screw. Using the fuse puller, rotate the tuning piston for a small peak of the order of 0.2 v in the voltmeter reading of 1.0 to 1.5 vdc. Take note of output. Tighten locking screw. Output may drop. Loosen locking screw and adjust tuning piston to compensate for drop and tighten screw again. Output should now be the same maximum as noted originally. Operate the RF level control to insure that tuning has been accomplished at the desired frequency; indicated by the voltmeter reading following the RF level control adjustment.

Following the same procedure, and at the same frequency (1219 mc), adjust C208 tuning piston using the voltmeter connected to C209 as an indicator.

Again follow the same procedure and adjust C215. This time, use the 413A as the indicating device.

Switch to 1130 mc. Adjust C201 for maximum as read on the voltmeter. Also adjust C206 in the same manner.

Using the 431A as an indicating device, adjust C213. Repeat the above operations until no further changes are indicated on the meters. Switch to 1049 mc. With special wrench, adjust cam follower on C203, C205, and C215 for maximum output.

Switch to 960 mc. Individually loosen cam locking screws on large cams and adjust for maximum output by rotating slightly with fingers. Repeat cam follower adjustment at 1049 mc and large cam adjustment at 960 mc until no more changes are observed.

At 10 mc intervals, in both bands, adjust capacitors C201, C206, and C213 for maximum output. Readjust slightly to maintain less than 1 db tracking error per stage.

### Pulse Voltmeter Sensitivity Adjustment

At any output frequency, with the 235A in the CW position, adjust RF level for red line. Next, pulse modulate (with Collins 578X1 Modulator) 235A in the NORMAL (NORMAL—PWR MEAS switch) position and CAL (Function Selector switch) position. Change to PWR MEAS (NORMAL—PWR MEAS switch) position and PWR MEAS (Function Selector switch) position. Adjust the PULSE SENS control (R429) so the RF MONITOR meter reads "4.5" for the highest of the above two conditions.

If the Signal Generator detector output is too low to meet this condition, additional output may be obtained by increasing the coupling between the Signal Generator detector resistor (R208) and the output tank coil (L209). If this adjustment is required, tracking of the output stage of the UHF Unit must be rechecked.

### RF MONITOR Meter Calibration

#### *Equipment Required*

1. HP Power Meter Model 431A or equivalent.
2. HP Thermistor Mount Model 478A or equivalent.

At 960 mc, with the piston attenuator all the way in, adjust the RF level control for —10 dbm on the Power Meter. Set the CW SENS control (R503), located on meter terminal board, for red line reading on the RF MONITOR Meter.

Check the RF output for red line at the following frequencies: 960, 1000, 1040, 1130, 1170, 1210 mc. The output curve (Output vs. Frequency) should be flat or have a characteristic sloping downward about 1 db across the frequency band. A slight increase upward, not to exceed 0.2 db in the center of the band, can be tolerated. Under no circumstances should the output show an increasing characteristic from low frequency to high frequency. To achieve this characteristic, the thermistor compensating coil L213 should be adjusted. This adjustment is critical and extremely sensitive.

At the frequency of lowest output and the attenuator all the way in, the RF level should be adjusted for —10.7 dbm on the Power Meter. Reset the CW SENS control (R503) for red line. Recheck meter zero. Repeat procedure for most accurate results.

Adjust the Piston Attenuator dial to read —10 dbm with attenuator all the way in. Loosen stop collar and reset it at 0.5 db beyond the —10 dbm mark (—9.5 dbm).

### Checking Detector Block Output

#### *Equipment Required*

1. Signal Generator capable of 0.8 volts output at 1220 mc
2. HP VTVM Model 410B or equivalent
3. HP T Probe 455A
4. 50-ohm termination

Using the 410B with 455A and 50-ohm termination, adjust the signal generator for an output of 0.8 volts at 1220 mc. Connect the signal generator to each detector block individually. In each instance, the output of the detector should be 0.5 vdc, or more, measured with the 410B. Replace the detector if output is low. It should be noted that the output of the XMTR DEMOD detector is positive and the outputs of both the FREQ MEAS and PWR MEAS detectors are negative.

## SERVICE NOTES

### General

When replacing tubes, it is important that great care is taken not to disturb the physical position of L213. The position is carefully set and supported at the factory.

The 235A, when shipped from the factory, has excess power output to take care of tube and component aging. Typical instruments have an excess of 5 db when new. It is recommended that when the maximum output will not go over "35" on the panel meter, consideration be given to replacement of tubes.

### Replacement of V201

The tuned circuit in the plate of V201 must be slightly detuned from the condition of maximum CW output in order to minimize overshoot on the leading edge of the DME pulses. As shipped from the factory, this overshoot is held to less than 5%. Replacement of this amplifier tube (V201) may require slight adjustment of the small cam relative to the shaft which is associated with that tube. This should be done for optimum pulse shape and has no effect on the low band operating conditions.

### Replacement of V203

It should be noted that when replacing V203 (UHF Osc.), it is desirable to recheck the actual frequencies generated at this point. This may be conveniently checked at J202, located inside the RF shield can. The output level here is sufficient to drive a counter directly. (Use HP 525C Frequency Converter Plug-in Unit).

### UHF Oscillator Tuning

Improper tuning of the UHF oscillator has been known to produce an effect similar to spurious output. With an oscilloscope pulse display from the MONITOR OUTPUT jack, if the scope sync is adjusted, the pattern will be seen to be a small pulse (similar to a blocking oscillator pulse) with a negative-going peak on the top of the main pulse. The small peak will be of the order of 5% of the main pulse height; followed by a slight 1 or 2% overshoot and will be non-synchronous with the DME pulses. This effect will not be restricted to certain DME channels. Realignment for maximum output and a check of the crystal frequencies is in order.

### Hum on Pulses

If "hum" is observed on the pulses, as seen at the MONITOR OUTPUT JACK, this generally can be traced to heater-cathode leakage in the V400A (6AU8) tube. See waveform in Figure 25.

### Ringing

It has been observed that "ringing" on the envelope, other than plain overshoot on the output pulse from the signal generator demodulator, may be due to a faulty capacitor, C237 (10uf). This capacitor is mounted near the MOD LEVEL control in the RF Unit. If the capacitance of C237 is excessively low, ringing will occur.

### Replacement of Resistors in the Circuit of V400B

Resistors R408 and R410 should be replaced in the field with parts of proper precision. If in doubt, the relative amplitudes of the signals delivered to the grid of V405A can be compared in the PULSE and CAL positions, by means of a suitable wide band oscilloscope, with the MOD LEVEL control set for the panel meter to read the same. If there is a difference of more than $\pm 2\%$, it is probable that one of these resistor values is incorrect. (See Section V Operational Guide for Output Level Accuracy.)

### Replacement of XMTR Demod Detector

When replacing the MA425 (A502) detector used in the XMTR DEMOD, care should be taken to select a diode whose reverse voltage characteristics do not show "avalanche" effects below 6.3 volts. If this is not done, a sharp flattening of the top of the pulse may be noted at power levels above +31 dbw. To check diode in 235A, feed the output of a DME transmitter into the RF jack. Check power of transmitter. The transmitter should be capable of 33 dbw. Observing the output of the XMTR DEMOD jack on an oscilloscope, the amplitude should be noted.

A 6 db pad should be added between the transmitter and the 235A RF jack. Amplitude will drop to 50% or less. For a satisfactory diode the amplitude should not drop less than 40% (See Fig. 24).

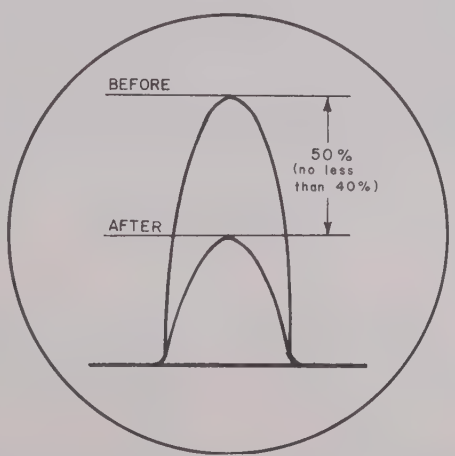
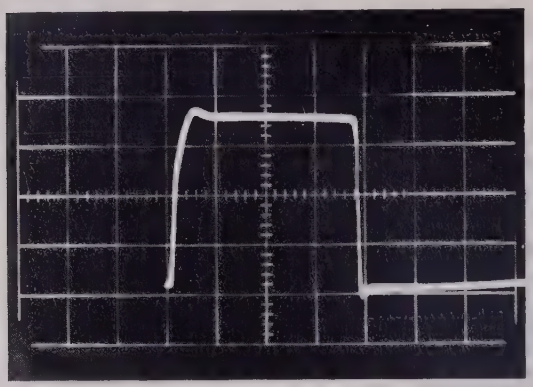
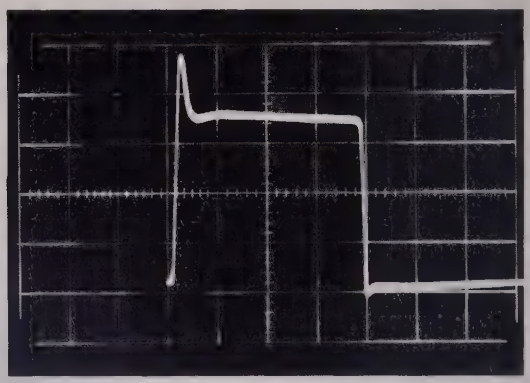


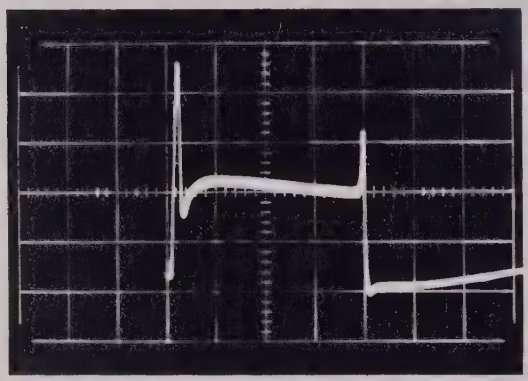

*Figure 24. XMTR DEMOD Detector Diode Check Waveform*



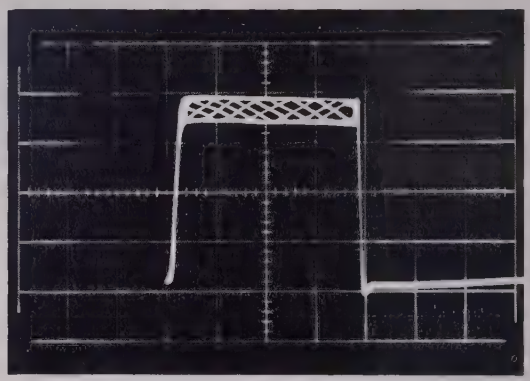
*(A)*
*Normal Pulse—Broken leading edge indicates intentional, slight detuning of the V201 amplifier stage to minimize overshoot.*



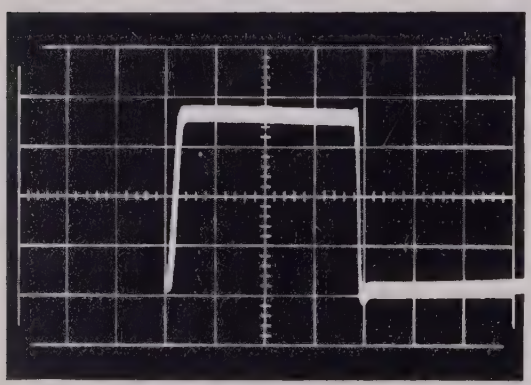
*(B)*
*Excessive Overshoot (Approximately 30%)*



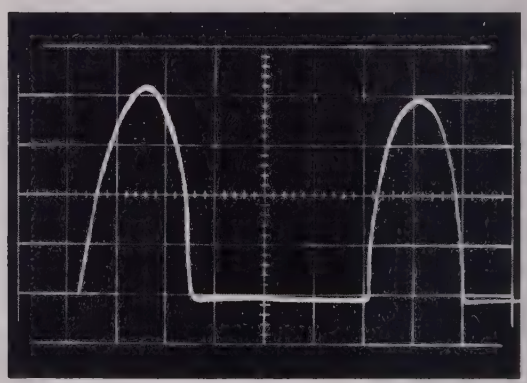
*(C)*
*Overmodulation (Saturation of V202) Modulation level too high.*



*(D)*
*Excessive spurious frequency (only about 17 db below the desired frequency) indicated by the beat note on the top of the pulse. Note that base line is not effected.*



*(E)*
*Excessive 60 cps hum indicated by broad trace width at pulse top and at base line.*



*(F)*
*Typical DME Pulse Pair*

NOTES
1. *All pulses observed at 235A MONITOR OUTPUT jack.*
2. *Waveforms (A) through (E)—235A modulated by Collins 578D-1.*
3. *Waveform (F)—Typical DME pulse pair from Collins 560E-1 Radio Set.*

**Figure 25. Waveforms—Type 235A**

# SECTION VII
# REPLACEABLE PARTS

## GENERAL

Tables of replaceable electrical and mechanical parts for the 235A are included in this section. Locations of these parts are given in Figures 26 through 45. When ordering replacement parts, specify the BRC part number and the description given in the replacement parts tables. See Section VI for detailed disassembly and assembly procedures and for adjustment and/or calibration procedures required after component replacement.

## LIST OF MANUFACTURERS

| Abbrev. | Manufacturer's Name |
|---|---|
| AB | Allen-Bradley Co. |
| AE | Arco Electronics, Inc. |
| AER | Aerovox Corp. |
| AH | Arrow-Hart & Hegeman Electric Co. |
| C-D | Cornell-Dubilier Electric Corp. |
| CRL | Centralab, Div. of Globe-Union, Inc. |
| CST | Chicago Standard Transformer Co. |
| CTS | CTS Corporation |
| DEC | Dage Electric Co., Inc. |
| ERC | Erie Resistor Corp. |
| GA | Good-All Electric Mfg. Co. |
| GE | General Electric Co. |
| GRE | Gremar Mfg. Co., Inc. |
| HBJ | Howard B. Jones Co. |
| HC | Hunt Corp. |
| H-P | Hewlett-Packard |
| JFD | JFD Electronics Corp. |
| JWM | J. W. Miller Co. |
| LEC | Lectrohm, Inc. |
| LTF | Littlefuse, Inc. |
| MA | Microwave Associates, Inc. |
| MEPCO | Mepco, Inc. |
| MOT | Motorola Semiconductor Div., Motorola, Inc. |
| SPR | Sprague Electric Co. |
| TMC | Tower Mfg. Corp. |
| VECO | Victory Engineering Co. |
| WEC | Weinchel Engineering Co. |
| WILCOR | Wilco Corp. |

## TABLE OF REPLACEABLE ELECTRICAL PARTS

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. TYPE NO. |
|---|---|---|---|---|---|
| | | VHF UNIT | | | |
| C100 | 47pf | Capacitor: Fixed, Ceramic, ±2-1/2%, 600 VDCW | 82115 | CRL | TCZ-47 |
| C101 | 1000pf | Capacitor: Fixed, Ceramic Disk, ±20%, 1000 VDCW | 82351 | SPR | 5GA-D10 |
| C102 | 0.01μf | Capacitor: Fixed, Ceramic Disk, +80% −20%, 600 VDCW | 82428 | CRL | DA048-003A |
| C103 | 1000pf | Capacitor: Fixed, Ceramic, Feedthru, GMV Tol., 500 VDCW | 82300 | AB | 5A5C-102W |
| C104 | 33pf | Capacitor: Fixed, Ceramic, ±2-1/2%, 600 VDCW | 82114 | CRL | TCZ-33 |
| C105 | 12pf | Capacitor: Fixed, Ceramic, ±0.6pf, 600 VDCW | 82045 | ERC | N1400A12 |
| C106, 107 | 47pf | Same as C100 | | | |
| C108 | 1pf | Capacitor: Fixed, Ceramic, ±0.25pf, 600 VDCW | 82046 | ERC | Tub. Ceramicon |
| C109, 110 | | Same as C101 | | | |
| C111 | | Same as C103 | | | |
| C112 | | Same as C100 | | | |
| C113-115 | 8-60pf | Capacitor: Variable, Mica, Compression, 175 VDCW | 84092 | AE | 40-404 |
| C116-118 | 3-35pf | Capacitor: Variable, Mica, Compression, 175 VDCW | 84096 | AE | 403 |
| C119-121 | 1.5-20pf | Capacitor: Variable, Mica, Compression, 175 VDCW | 84095 | AE | 402 |
| C122 | 5pf | Capacitor: Fixed, Ceramic, ±0.25pf, 600 VDCW | 82047 | ERC | N1400A5 |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| C123-132 | 0.8-18pf | Capacitor: Variable, with Invar. slug | 84093 | JFD | VC5G |
| C133 | | Same as C100 | | | |
| C134 | | Same as C101 | | | |
| C135-137 | | Same as C103 | | | |
| C138 | | Same as C100 | | | |
| C139-141 | | Same as C113 | | | |
| C142-144 | | Same as C116 | | | |
| C145-147 | | Same as C119 | | | |
| C148 | | Same as C122 | | | |
| C149-158 | | Same as C123 | | | |
| C159 | | Same as C101 | | | |
| C160 | 680pf | Capacitor: Fixed, Ceramic, ±68pf, 600 VDCW | 82245 | ERC | GP2K680 |
| C161 | | Same as C103 | | | |
| C162 | 0.1μf | Capacitor: Fixed, Mylar, 200 VDCW | 83147 | GA | 663A |
| C163 | 2pf | Capacitor: Fixed, Ceramic, ±0.25pf, 500 VDCW | 82131 | ERC | P-120K2 |
| C164 | 18pf | Capacitor: Fixed, Ceramic, ±0.5pf, 600 VDCW | 82126 | CRL | TCN-18 |
| C165 | 150pf | Capacitor: Fixed, Ceramic, ±10%, 600 VDCW | 82223 | ERC | GP1332 150 |
| C166, 167 | | Same as C101 | | | |
| C168 | | Same as C100 | | | |
| C169 | | Same as C102 | | | |
| C170-173 | | Same as C103 | | | |
| C174-176 | | Same as C101 | | | |
| J100 | | Connector, RF: UG-1094/U | 303430 | DEC | 667-2 |
| L100, 101 | 100μh | Choke, RF | 85601 | | |
| L102 | 0.51μh | Choke, RF | 307617 | | |
| L103 | 0.42μh | Choke, RF | 307618 | | |
| L104 | 0.35μh | Choke, RF | 307619 | | |
| L105 | 0.3μh | Choke, RF | 307620 | | |
| L106 | 0.198μh | Coil, RF | 307585 | | |
| L107 | 0.248μh | Coil, RF | 307586 | | |
| L108 | 0.280μh | Coil, RF | 307587 | | |
| L109 | 0.360μh | Coil, RF | 307588 | | |
| L110 | 0.411μh | Coil, RF | 307589 | | |
| L111 | 0.493μh | Coil, RF | 307590 | | |
| L112 | 0.685μh | Coil, RF | 307591 | | |
| L113 | 0.910μh | Coil, RF | 307597 | | |
| L114 | 1.31μh | Coil, RF | 307592 | | |
| L115 | 10μh | Choke, RF | 85591 | | |
| L116 | 0.181μh | Coil, RF | 307607 | | |
| L117 | 0.23μh | Coil, RF | 307605 | | |
| L118 | 0.19μh | Coil, RF | 307606 | | |
| L119 | 0.276μh | Coil, RF | 307604 | | |
| L120 | 0.328μh | Coil, RF | 307603 | | |
| L121 | 0.361μh | Coil, RF | 307601 | | |
| L122 | 0.422μh | Coil, RF | 307600 | | |
| L123 | 0.576μh | Coil, RF | 307599 | | |
| L124 | 0.73μh | Coil, RF | 307598 | | |
| L125 | | Same as L115 | | | |
| L126A, B | 0.267μh | Coil, Doubler | 307608 | | |
| L127A, B | 0.274μh | Coil, Doubler | 307609 | | |
| L128A, B | 0.315μh | Coil, Doubler | 307610 | | |
| L129A, B | 0.377μh | Coil, Doubler | 307611 | | |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| L130A, B | 0.470μh | Coil, Doubler | 307612 | | |
| L131A, B | 0.545μh | Coil, Doubler | 307613 | | |
| L132A, B | 0.670μh | Coil, Doubler | 307614 | | |
| L133A, B | 0.810μh | Coil, Doubler | 307615 | | |
| L134A, B | 1.125μh | Coil, Doubler | 307616 | | |
| L135 | 10μh | Choke, RF | 85593 | | |
| L136 | 5μh | Choke, RF | 300327 | | |
| L137 | | Same as L115 | | | |
| L138, 139 | 550μh | Choke, RF: ±10% | 307012 | JWM | 4649 |
| L140 | 90μh | Choke, RF | 307008 | | |
| L141-143 | 3.5μh | Choke, RF: ±5% | 307628 | | |
| P100 | | Connector, RF: Angle | 306758 | GRE | 5042 |
| R100 | 47Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80041 | AB | EB |
| R101 | 22KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80472 | AB | EB |
| R102 | 220Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80188 | AB | EB |
| R103 | 15KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80336 | AB | EB |
| R104, 105 | 4.7KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80304 | AB | EB |
| R106 | 180Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80222 | AB | EB |
| R107 | | Same as R101 | | | |
| R108 | 47KΩ | Resistor: Fixed, Composition, ±5%, 1W | 80470 | AB | GB |
| R109 | 470KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80640 | AB | EB |
| R110 | 150Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80098 | AB | EB |
| R111 | 68Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80057 | AB | EB |
| R112 | 100KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80517 | AB | EB |
| R113 | | Same as R110 | | | |
| R114 | | Same as R101 | | | |
| R115 | 1KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80148 | AB | EB |
| R116 | | Same as R104 | | | |
| R117 | 4.7KΩ | Resistor: Fixed, Composition, ±5%, 2W | 80766 | AB | HB |
| R118-120 | 1KΩ | Resistor; Fixed, Composition, ±5%, 2W (P/O Chokes L141-143) | 80151 | AB | HB |
| R121 | | Same as R102 | | | |
| S100A-C | | Switch, Rotary: Tens Oscillator | 307476 | | |
| S100D-F | | Switch, Rotary: Tens Mixer | 307477 | | |
| S100G-J | | Switch, Rotary: Tens Amplifier | 307478 | | |
| S101A, D | | Switch, Rotary: Units Oscillator | 307473 | | |
| S101B | | Switch, Rotary: Units Mixer | 307474 | | |
| S101C | | Switch, Rotary: Units Amplifier | 307475 | | |
| V100A, B | | Tube, Electron: 5670 | | | |
| V101 | | Tube, Electron: 6AS6 | | | |
| V102 | | Tube, Electron: 6AK5 | | | |
| V103 | | Tube, Eletcron: 6AH6 | | | |
| V104A, B | | Same as V100 | | | |
| Y100 | | Crystal: 25 Mc ±0.005% | 307464 | HC | CR55/U |
| Y101 | | Crystal: 30 Mc ±0.005% | 307465 | HC | CR55/U |
| Y102 | | Crystal: 35 Mc ±0.005% | 307466 | HC | CR55/U |
| Y103 | | Crystal: 40 Mc ±0.005% | 307467 | HC | CR55/U |
| Y104 | | Crystal: 45 Mc ±0.005% | 307468 | HC | CR55/U |
| Y105 | | Crystal: 50 Mc ±0.005% | 307469 | HC | CR55/U |
| Y106 | | Crystal: 55 Mc ±0.005% | 307470 | HC | CR55/U |
| Y107 | | Crystal: 60 Mc ±0.005% | 307471 | HC | CR55/U |
| Y108 | | Crystal: 65 Mc ±0.005% | 307472 | HC | CR55/U |
| Y109 | | Crystal: 6.1000 Mc ±0.01% | 307452 | HC | HC18 |
| Y110 | | Crystal: 6.6000 Mc ±0.01% | 307453 | HC | HC18 |
| Y111 | | Crystal: 7.1000 Mc ±0.01% | 307454 | HC | HC18 |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| Y112 | | Crystal: 7.6000 Mc ±0.01% | 307455 | HC | HC18 |
| Y113 | | Crystal: 8.1000 Mc ±0.01% | 307456 | HC | HC18 |
| Y114 | | Crystal: 8.6000 Mc ±0.01% | 307457 | HC | HC18 |
| Y115 | | Crystal: 9.1000 Mc ±0.01% | 307458 | HC | HC18 |
| Y116 | | Crystal: 9.6000 Mc ±0.01% | 307459 | HC | HC18 |
| Y117 | | Crystal: 10.1000 Mc ±0.01% | 307460 | HC | HC18 |
| Y118 | | Crystal: 10.6000 Mc ±0.01% | 307461 | HC | HC18 |
| | | UHF UNIT | | | |
| AT200 | | Attenuator, Variable | 306787 | | |
| C200 | 5pf | Capacitor: Fixed, Ceramic, ±0.25pf | 82003 | AER | HIQ |
| C201 | 0.7-9pf | Capacitor: Variable, Piston Type | 84047 | JFD | VC1G |
| C202 | 470pf | Capacitor: Fixed, Feedthru, GMV Tol. | 83157 | AB | FA5C-471W |
| C203 | 0.7-3pf | Capacitor: Variable, | 307582 | | |
| C204 | | Same as C202 | | | |
| C205 | | Same as C162 | | | |
| C206 | | Same as C201 | | | |
| C207 | | Same as C202 | | | |
| C208 | | Same as C203 | | | |
| C209, 210 | 100pf | Capacitor: Fixed, Feedthru, ±10% | 83156 | AB | FA5C-101W |
| C211 | 150pf | Capacitor: Fixed, Special | 307364<br>307381 | | |
| C212 | 33pf | Capacitor: Fixed, Feedthru, ±10% | 83155 | AB | FA5C-101W |
| C213 | | Same as C201 | | | |
| C214 | | Same as C202 | | | |
| C215 | | Same as C203 | | | |
| C216 | 50pf | Capacitor, Fixed, Special | 307370<br>307381 | | |
| C217 | | Same as C103 | | | |
| C218 | | Trimmer and Contact Assy. | 307289 | | |
| C219 | | Trimmer and Tab Assy. | 307400 | | |
| C220 | 1000pf | Capacitor: Fixed, Feedthru, ±10%, 500 VDCW | 82307 | ERC | 370CB |
| C221, 222 | | Same as C100 | | | |
| C223 | | Same as C220 | | | |
| C224 | | Trimmer and Tab Assy. | 307288 | | |
| C225 | | Same as C218 | | | |
| C226 | | Same as C104 | | | |
| C227 | | Same as C202 | | | |
| C228 | 100pf | Capacitor: Fixed, Standoff, ±20%, 500 VDCW | 82153 | AB | SS5A1012 |
| C229 | | Same as C103 | | | |
| C230 | | Same as C224 | | | |
| C231 | | Same as C218 | | | |
| C232 | 1pf | Capacitor: Fixed, Ceramic, ±0.1pf | 82037 | ERC | NP0A3 |
| C233, 234 | | Same as C202 | | | |
| C235 | | Same as C224 | | | |
| C236 | | Same as C218 | | | |
| C237 | 10μf | Capacitor: Fixed, Electrolytic, −10% +250%, 6 VDCW | 83131 | AER | PWE6010 |
| C238-242 | | Same as C103 | | | |
| CR200 | | Rectifier, Diode | 98011 | MA | MA-424-Rev. |
| CR201, 202 | | Diode, Zener: Breakdown | 98014 | MOT | 1.5M7.5Z5 |
| J200-202 | | Connector, RF: UG290/U | 302353 | DEC | 055-1 |
| L200 | 0.1μh | Choke, RF | 307007 | | |
| L201 | 0.2μh | Choke, RF | 307009 | | |
| L202 | 0.08μh | Coil, RF | 307627 | | |
| L203 | | Loop, Pickup: Special, Not Replaceable | | | |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| L204 | | Same as L201 | | | |
| L205 | 0.08μh | Coil, RF | 307626 | | |
| L206 | | Loop, Pickup: Special, Not Replaceable | | | |
| L207 | | Loop, Pickup: Special, Not Replaceable | | | |
| L208 | 0.23μh | Choke, RF: Includes R206 | 307624 | | |
| L209 | 0.014μh | Coil, RF | 307373 | | |
| L210 | | Loop, Pickup: Part of AT200 | | | |
| L211 | | Loop, Pickup: Part of AT200 | | | |
| L212 | | Loop, Pickup: Part of AT200 | | | |
| L213 | 0.145μh | Choke, RF: Part of AT200 | 307629 | | |
| L214 | 0.70μh | Coil, RF | 307622 | | |
| L215 | 0.145μh | Coil, RF | 307621 | | |
| L216 | | Same as L140 | | | |
| L217 | 0.053μh | Coil, RF | 307630 | | |
| L218 | 0.5μh | Choke, RF | 307005 | | |
| L219 | 0.22μh | Coil, RF Solenoid | 85538 | | |
| L220 | | Loop, Pickup: Special, Not Replaceable | | | |
| L221 | 0.055μh | Coil, RF | 307631 | | |
| L222, 223 | | Same as L218 | | | |
| L224-227 | 0.17μh | Choke, RF | 307003 | | |
| P200 | | Same as P100 | | | |
| P201 | | Connector, RF: UG-260/U | 303216 | DEC | 073-1 |
| P202 | | Same as P100 | | | |
| R200 | 270Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80232 | AB | EB |
| R201 | 100Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80062 | AB | EB |
| R202, 203 | | Same as R102 | | | |
| R204 | 10Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80006 | AB | EB |
| R205 | | Same as R201 | | | |
| R206 | 3.9KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80287 | AB | EB |
| R207 | 50Ω | Resistor: Fixed, Carbon Film, ±1%, 1/4W, Part of AT200 | | | |
| R208 | 51Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80088 | AB | EB |
| | 390Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80182 | AB | EB |
| R210 | | Same as R102 | | | |
| R211 | | Same as R201 | | | |
| R212 | 82Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80059 | AB | EB |
| R213 | | Same as R101 | | | |
| R214 | | Same as R102 | | | |
| R215 | 1.2KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80201 | AB | EB |
| R216 | | Same as R101 | | | |
| R217 | 18KΩ | Resistor: Fixed, Composition, ±5%, 1/2W | 80381 | AB | EB |
| R218 | 240Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80174 | AB | EB |
| R220 | 100Ω | Resistor: Variable, Composition, ±5%, 2W | 81016 | CTS | 95 |
| R221 | 560Ω | Resistor: Fixed, Composition, ±5%, 1/2W | 80136 | AB | EB |
| RT200 | | Thermistor, Bead | 80737 | WECO | 32A3 |
| RT201 | | Thermistor, Disc | 80736 | WECO | D168392 |
| S200A1-A4 | | Switch and Trimmer Assy. | 307289 | | |
| S200B | | Switch, SPDT | 307952 | | |
| T200 | | Transformer, Filament: Primary 115V, Secondary 6.3V at 1.35A | 85003 | | |
| TP200 | | Test Point—Terminal on C227 | | | |
| TP201 | | Test Point—Terminal on C233 | | | |
| V200, 201 | | Tube, Electron: 5876 | | | |
| V202 | | Tube, Electron: GL6299 | | | |
| V203 | | Tube, Electron: 5670 | | | |
| V204 | | Tube, Electron: 6AK5 | | | |
| V205 | | Tube, Electron: 6AN4 | | | |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| Y200 | | Crystal: 37.4083 Mc, ±0.0025% | 307462 | HC | CR23/U |
| Y201 | | Crystal: 44.4917 Mc, ±0.0025% | 307463 | HC | CR23/U |
| | | RF FILTERS | | | |
| C300-303 | | Same as C202 | | | |
| C304 | 10pf | Capacitor: Fixed, Feedthru, ±10% | 83158 | AB | FA5C-1001 |
| C305 | | Same as C212 | | | |
| C306 | 150pf | Capacitor: Fixed, Feedthru, ±10% | 83160 | AB | FA5C-1511 |
| C307-311 | | Same as C202 | | | |
| C312-315 | | Same as C103 | | | |
| C316 | 82pf | Capacitor: Fixed, Feedthru, ±10% | 83159 | AB | FA5C-82001 |
| C317, 318 | | Same as C306 | | | |
| C319-323 | | Same as C103 | | | |
| C324-327 | | Same as C202 | | | |
| C328 | | Same as C304 | | | |
| C329, 330 | | Same as C212 | | | |
| C331-335 | | Same as C202 | | | |
| FL300 | | Filter Assembly, RF: #1 (See Figure 33 for component breakdown) | 306790 | | |
| FL301 | | Filter Assembly, RF: #2 (See Figure 34 for components breakdown) | 306791 | | |
| L300-302 | 10μh | Choke, RF | 307444 | | |
| L303 | 5μh | Choke, RF | 300327 | | |
| L304 | 0.7μh | Choke, RF | 307442 | | |
| L305 | 1.4μh | Choke, RF | 307443 | | |
| L306 | 1μh | Choke, RF | 307441 | | |
| L307, 308 | | Same as L303 | | | |
| L309 | | Same as L300 | | | |
| L310, 311 | 50μh | Choke, RF | 307445 | | |
| L312-314 | | Same as L300 | | | |
| L315 | | Same as L303 | | | |
| L316, 317 | | Same as L305 | | | |
| L318 | 0.5μh | Choke, RF | 307005 | | |
| L319, 320 | | Same as L303 | | | |
| L321 | | Same as L300 | | | |
| L322, 323 | | Same as L310 | | | |
| | | PULSE VOLTMETER | | | |
| C400 | 0.01μf | Capacitor: Fixed, Mylar, 200 VDCW | 83146 | GA | 663A |
| C401 | | Same as C162 | | | |
| C402 | 800pf | Capacitor: Fixed, Ceramic, +5% −7-1/2% | 82049 | ERC | Ceramicon |
| C403 | | Same as C162 | | | |
| C404 | | Same as C400 | | | |
| C405-407 | | Same as C162 | | | |
| C408 | 30pf | Capacitor: Fixed, Ceramic, ±2% | 82048 | ERC | CC25CH300G |
| C409-411 | | Same as C162 | | | |
| C412 | | Same as C101 | | | |
| C413 | 220pf | Capacitor: Fixed, Ceramic, ±5% | 82222 | ERC | GP2K |
| C414 | 0.5pf | Capacitor: Fixed, Ceramic, ±5% | 83149 | GA | 663A |
| C415 | | Same as C162 | | | |
| C416 | 1500pf | Capacitor: Fixed, Ceramic ±20% | 82331 | SPR | 5GA-D15 |
| C417, 418 | | Same as C237 | | | |
| C419 | 0.25μf | Capacitor: Fixed, Mylar, 200 VDCW | 83148 | GA | 663A |
| C420, 421 | | Same as C162 | | | |
| C422 | | Same as C100 | | | |
| C423, 424 | | Same as C162 | | | |
| C425 | | Same as C400 | | | |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| J400-402 | | Connector | 89138 | DEC | DM-1-310-1 |
| J403, 404 | | Connector, RF: UG-262/U | 307480 | DEC | 121-1 |
| J405-407 | | Connector: UG-625A/U | 307044 | DEC | 667-1 |
| L400 | 25$\mu$h | Choke, RF | 85428 | | |
| P400-402 | | Connector | 89137 | DEC | 1-629-1 |
| P403, 404 | | These circuit symbols not assigned | | | |
| P405, 406 | | Connector | 303216 | DEC | 073-1 |
| P407 | | Connector | 89137 | DEC | 1-629-1 |
| R400 | 75Ω | Resistor: Fixed, Composition, ±5%, 1/2 W | 80732 | AB | EB |
| R401 | | Same as R109 | | | |
| R402 | | Same as R111 | | | |
| R403 | 2.7KΩ | Resistor: Fixed, Composition, ±5%, 1 W | 80774 | AB | GB |
| R404 | 10KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80361 | AB | EB |
| R405 | | Same as R109 | | | |
| R406 | 680Ω | Resistor: Fixed, Composition, ±5%, 1/2 W | 80138 | AB | EB |
| R407, 408 | | Same as R109 | | | |
| R409 | | Same as R209 | | | |
| R410 | 5180Ω | Resistor: Fixed, Carbon Film, ±1%, 1/2 W | 80315 | WILCOR | CP 1/2 |
| R411-417 | | Same as R109 | | | |
| R418 | 8.2KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80326 | AB | EB |
| R419 | 2.2KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80256 | AB | EB |
| R420 | | Same as R404 | | | |
| R421 | 56KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80556 | AB | EB |
| R422 | | Same as R109 | | | |
| R423 | | Same as R421 | | | |
| R424 | | Same as R419 | | | |
| R425 | 5KΩ | Resistor: Variable, Composition, 1/2 W | 81081 | CTS | 45 |
| R426 | 47KΩ | Resistor; Fixed, Composition, ±5%, 2 W | 80494 | AB | HB |
| R427 | 10MEGΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80682 | AB | EB |
| R428 | | Same as R421 | | | |
| R429 | 250Ω | Resistor: Variable, Composition, 1/2 W | 81220 | CTS | 45 |
| R430 | | Same as R406 | | | |
| R431 | | Same as R109 | | | |
| R432 | | Same as R201 | | | |
| R433, 434 | | Same as R104 | | | |
| R435 | | Same as R109 | | | |
| R436 | 750Ω | Resistor: Fixed, Composition, ±5%, 1/2 W | 80763 | AB | EB |
| R437 | | Same as R201 | | | |
| R438 | 240Ω | Resistor: Fixed, Composition, ±5%, 1/2 W | 80174 | AB | EB |
| R439 | | Same as R404 | | | |
| R440 | 5.76KΩ | Resistor: Fixed, Carbon Film, ±1%, 1/2 W | 80913 | MEPCO | C20 |
| S400A1, 2 | | Switch, Rotary | 306706 | | |
| S400B1-4 | | Switch, Rotary | 306705 | | |
| V400A, B | | Tube, Electron: 6AU8 | | | |
| V401A, B | | Tube, Electron: 5687 | | | |
| V402A, B | | Tube, Electron: 6AL5 | | | |
| V403A, B | | Tube, Electron: 12AT7 | | | |
| V404A, B | | Same as V402 | | | |
| V405A, B | | Tube, Electron: 12AX7 | | | |
| | | DETECTOR, ATTENUATOR, AND METERING CIRCUITS | | | |
| A500 | | Wavemeter Assembly | 308363 | | |
| A501 | | Power Measure Detector | 306783 | | |
| A502 | | Transmitter Demodulator Detector | 306781 | | |
| A503 | | Frequency Measure Detector | 306782 | | |
| AT500 | | Attenuator: 53db | 306681 | WEC | 823-53 |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| AT501 | | Attenuator: 4db | 306682 | WEC | 685-4 |
| AT502 | | Power Divider | 307351 | | |
| AT503 | | Dual Coupler | 306816 | | |
| C500-502 | 50pf | Special: Not furnished as replaceable part | | | |
| CR500 | | Same as CR200 | | | |
| CR501 | | Semiconductor, Diode | 98013 | MA | MA-425 Rev. |
| CR502 | | Same as CR200 | | | |
| J500-502 | | Connector, RF | 304513 | | |
| J503, 504 | | Connector, RF: P/O Frequency Meter—Not furnished separately | | | |
| J505 | | Connector, RF: Angle | 307403 | | |
| J506, 507 | | Connector, RF | 307382 | | |
| J508 | | Connector, RF: Part of AT500—Not furnished separately | | | |
| J509, 510 | | Connector, RF: UG-58A/U | 307657 | DEC | 019-1 |
| J511 | | Connector, RF: Angle | 307420 | DEC | 2466-1 |
| J512 | | Connector, RF: Angle | 307402 | | |
| J513, 514 | | Same as J506 | | | |
| J515 | | Same as J200 | | | |
| J516 | | Connector, RF | 307564 | | |
| J517 | | Same as J403 | | | |
| J518 | | Connector, Receptacle: 8 prong | 303079 | HBJ | S-308-AB |
| L500, 501 | | Loop: Part of AT503—Not furnished separately | | | |
| M500 | | Meter: 200$\mu$a, 55$\Omega$ | 306710 | | |
| P500-505 | | Connector, RF: UG-88/U | 94156 | | |
| P506, 507 | | Connector, RF | 306991 | | |
| P508 | | Connector, RF: UG-536A/U | 307479 | DEC | 2460-1 |
| P509 | | Connector, RF: Part of AT500—Not furnished separately | | | |
| P510, 511 | | Connector, RF: Part of AT501—Not furnished separately | | | |
| P512 | | Same as P500 | | | |
| P513, 514 | | Same as P506 | | | |
| P515 | | Same as P500 | | | |
| P516, 517 | | These circuit symbols not assigned | | | |
| P518 | | Connector, Plug: 8 contact | 89145 | HBJ | P-308-CCT-63A-AB |
| R500 | 300$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80244 | AB | EB |
| R501 | | Same as R106 | | | |
| R502 | 120$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80099 | AB | EB |
| R503 | 500$\Omega$ | Resistor: Variable, Composition, 1/2 W | 81074 | CTS | 45 |
| R504 | | Same as R500 | | | |
| R505 | | This circuit symbol not assigned | | | |
| R506 | 2.5K$\Omega$ | Resistor: Variable, Composition, 2 W | 81221 | AB | J |
| R507 | 6K$\Omega$ | Resistor: Fixed, Wirewound, $\pm$5%, 5 W | 80501 | LEC | C5 |
| R508 | 200$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80768 | AB | EB |
| R509 | 620$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80191 | AB | EB |
| R510 | 12K$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1 W | 80767 | AB | GB |
| R511 | 25K$\Omega$ | Resistor: Variable, Composition, 2W | 81222 | AB | J |
| R512 | 33$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80032 | AB | EB |
| R513 | | Same as R110 | | | |
| R514 | | Same as R201 | | | |
| R515-517 | 470$\Omega$ | Resistor: Fixed, Composition, $\pm$5%, 1/2 W | 80168 | AB | EB |
| R518-520 | | Same as R207 | | | |
| R521-523 | 50$\Omega$ | Resistor: Fixed, Carbon Film, $\pm$1%, 1/2 W | 80726 | MEPCO | C15 |
| S500 | | Switch, Coaxial | 306719 | | |

| CIRCUIT SYMBOL | VALUE | DESCRIPTION | BRC PART NO. | MFG. | MFG'S. PART NO. |
|---|---|---|---|---|---|
| | | POWER SUPPLY | | | |
| C600, 603 | 40-40μf | Capacitor: Fixed, Electrolytic, 250 VDCW (with insulator) | 83152 | C-D | XB0241 |
| C601, 602 | 40-40μf | Capacitor: Fixed, Electrolytic, 150 VDCW (with mtg. strap) | 83153 | C-D | EDL4415SS |
| C604 | | Same as C162 | | | |
| C605, 606 | 500μf | Capacitor: Fixed, Electrolytic, 25 VDCW | 83167 | C-D | BR500-25S |
| C607 | | Same as C162 | | | |
| CR600 | | Rectifier, Silicon: 500 PIV, 0.5A, 1N1764 | 98006 | | |
| CR601, 602 | | Rectifier, Silicon: 400 PIV, 0.5A, 1N1763 | 91100 | | |
| CR603 | | Same as CR600 | | | |
| CR604 | | Same as CR201 | | | |
| CR605 | | Rectifier, Diode: 1N465 | 98010 | | |
| CR606, 607 | | Rectifier, Diode | 98015 | MOT | 1.5M82Z10 |
| DS600 | | Lamp, Incandescent: Bayonet base, 0.15A, 6-8V | 90904 | GE | #47 |
| F600 | | Fuse: 1.5A, 115 V | 93250 | LTF | 3AG |
| | | Fuse: 0.75A, 230 V | 95010 | LTF | 3AG |
| J601 | | Connector, Receptacle: 10 contacts | 303283 | HPJ | S-310-AB |
| J602, 603 | | Connector, Receptacle: 6 contacts | 301754 | HBJ | S-306-AB |
| L600 | .75h | Choke, Filter: 200 MA, 32Ω | 85439 | SEC | C-2343 |
| | | Note: Replaces 85438 used in early instruments. | | | |
| P600 | | Connector, Receptacle: male, 3-pin | 308087 | TMC | H-1061-IG |
| P601 | | Connector, Plug: 10 contact | 303335 | HBJ | P-310-CCT |
| P602 | | Connector, Plug: 6 contact | 301749 | HBJ | P-306-CCT |
| P603 | | Connector, Plug: 6 contact | 89120 | HBJ | P-306-FHT |
| R600 | 680Ω | Resistor: Fixed, Composition, ±5%, 1 W | 80137 | AB | GB |
| R601 | 18KΩ | Resistor: Fixed, Composition, ±5%, 2 W | 80843 | AB | HB |
| R602 | 1750Ω | Resistor: Fixed, Wirewound, ±5%, 10 W, with mtg. clamp | 80512 | SPR | 10KT |
| R603 | 39KΩ | Resistor: Fixed, Composition, ±5%, 1 W | 80429 | AB | GB |
| R604 | | Same as R206 | | | |
| R605 | 27KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80463 | AB | EB |
| R606, 607 | 1KΩ | Resistor: Variable, Composition, ±10%, 1/2 W | 81080 | CTS | 45 |
| R608 | 18KΩ | Resistor: Fixed, Composition, ±5%, 1 W | 80406 | AB | GB |
| R609 | 68KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80549 | AB | EB |
| R610, 611 | 2.7KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80765 | AB | EB |
| R612, 613 | | Same as R515 | | | |
| R614 | | Same as R512 | | | |
| R615, 616 | 33Ω | Resistor: Fixed, Composition, ±5%, 1 W | 80771 | AB | GB |
| R617 | 100KΩ | Resistor: Variable, Composition, 1/3 W | 81082 | CTS | 45 |
| R618 | 1.2MEGΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80646 | AB | EB |
| R619 | 620KΩ | Resistor: Fixed, Composition, ±5%, 1/2 W | 80618 | AB | EB |
| R620 | 510Ω | Resistor: Fixed, Composition, ±5%, 1/2 W | 80129 | AB | EB |
| S600 | | Switch, Toggle: DPDT | 88059 | AH | 81027CE |
| S601 | | Switch, Voltage | 88003 | H-P | 3101-0033 |
| T600 | | Transformer, Power: Primary 115/230 VAC, 50-420 CPS | 306686 | | |
| V600 | | Tube, Electron: 6AU6 | | | |
| V601 | | Tube, Electron: 6080 | | | |
| V602 | | Tube, Electron: 5651 | | | |
| W600 | | Power Cord Assembly | 308086 | | |

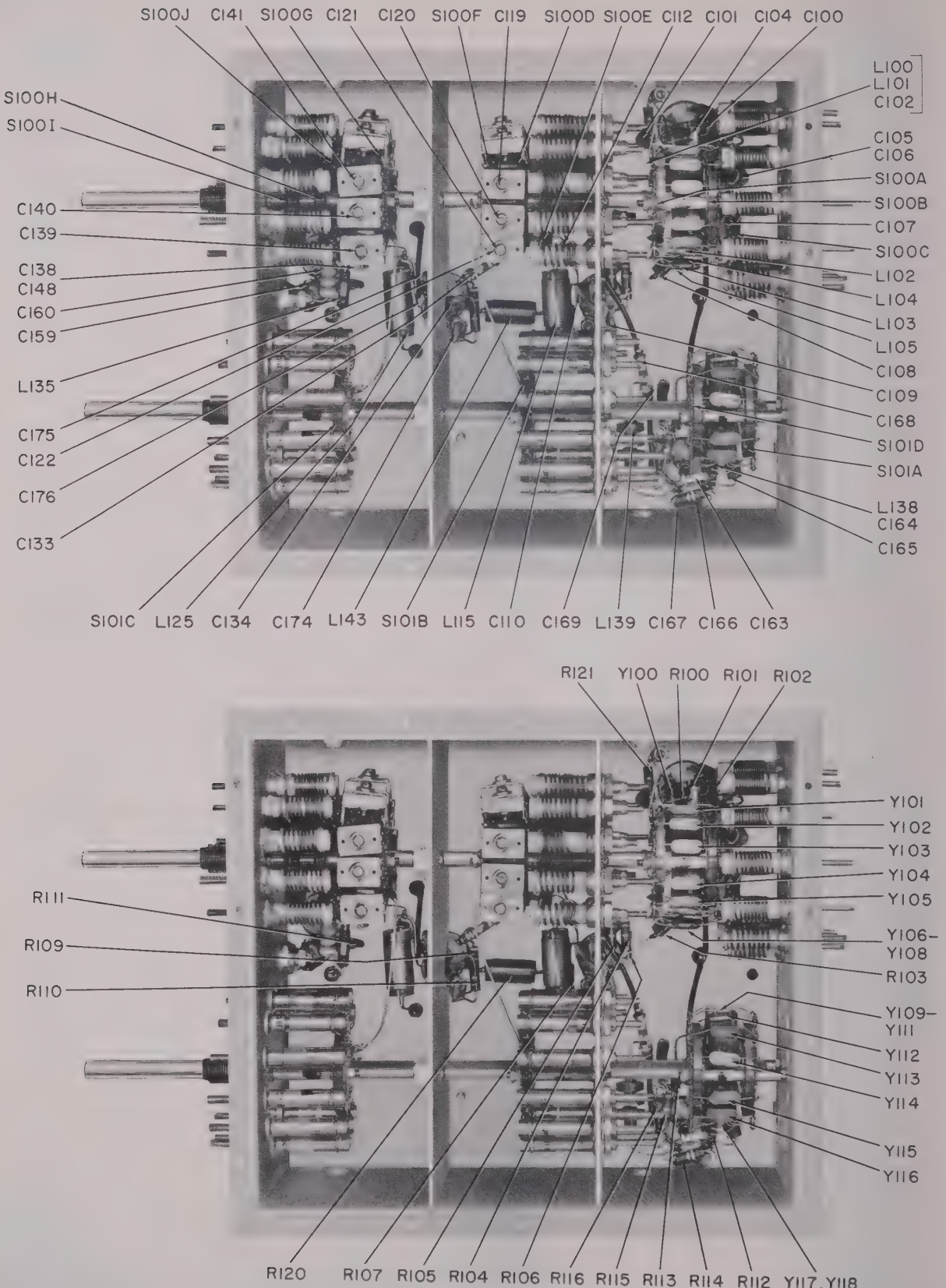



*Figure 26. VHF Unit—Top View*

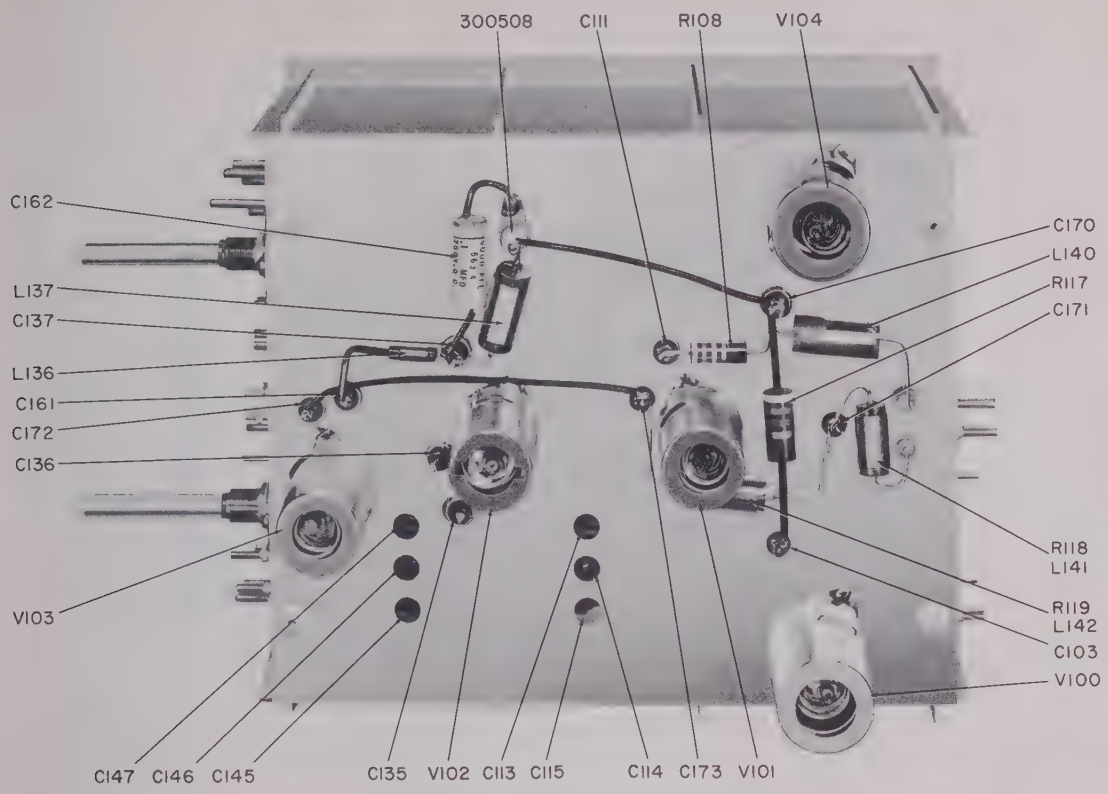



*Figure 27. VHF Unit—Bottom View*

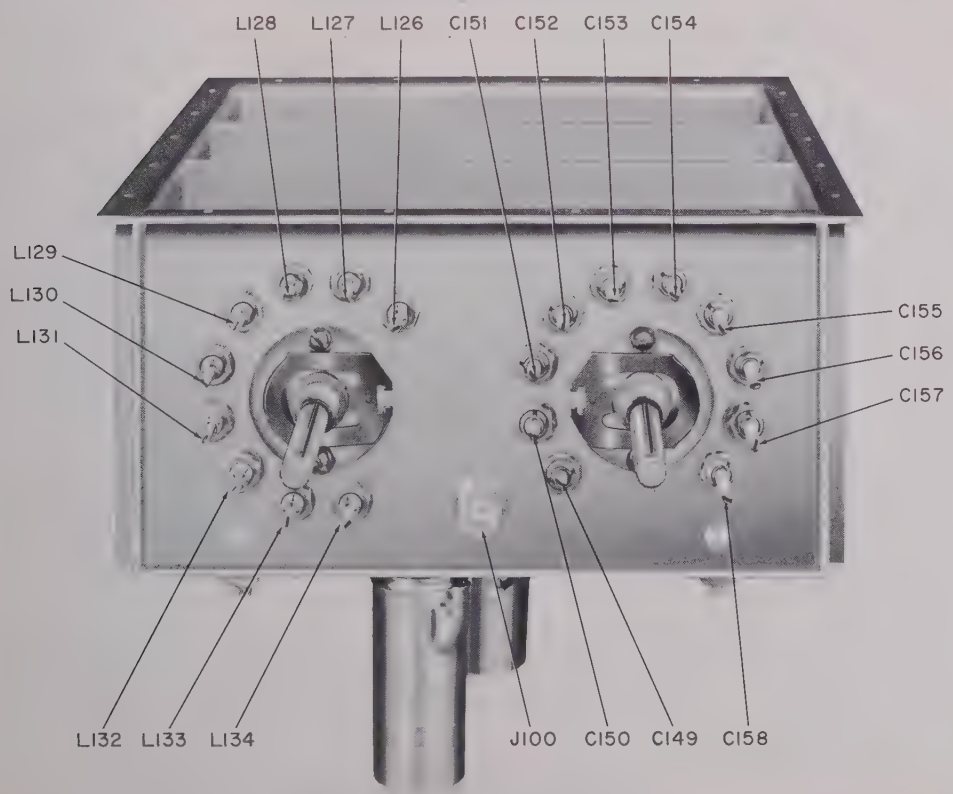



*Figure 28. VHF Unit—Front View*

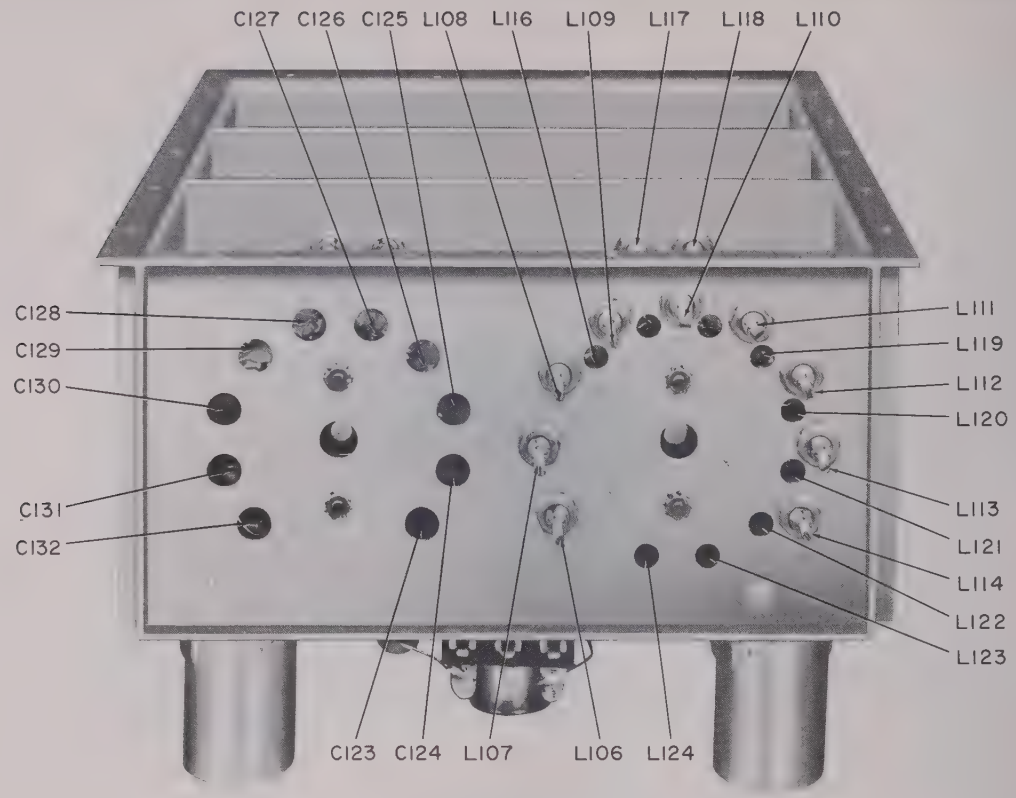



*Figure 29. VHF Unit—Rear View*

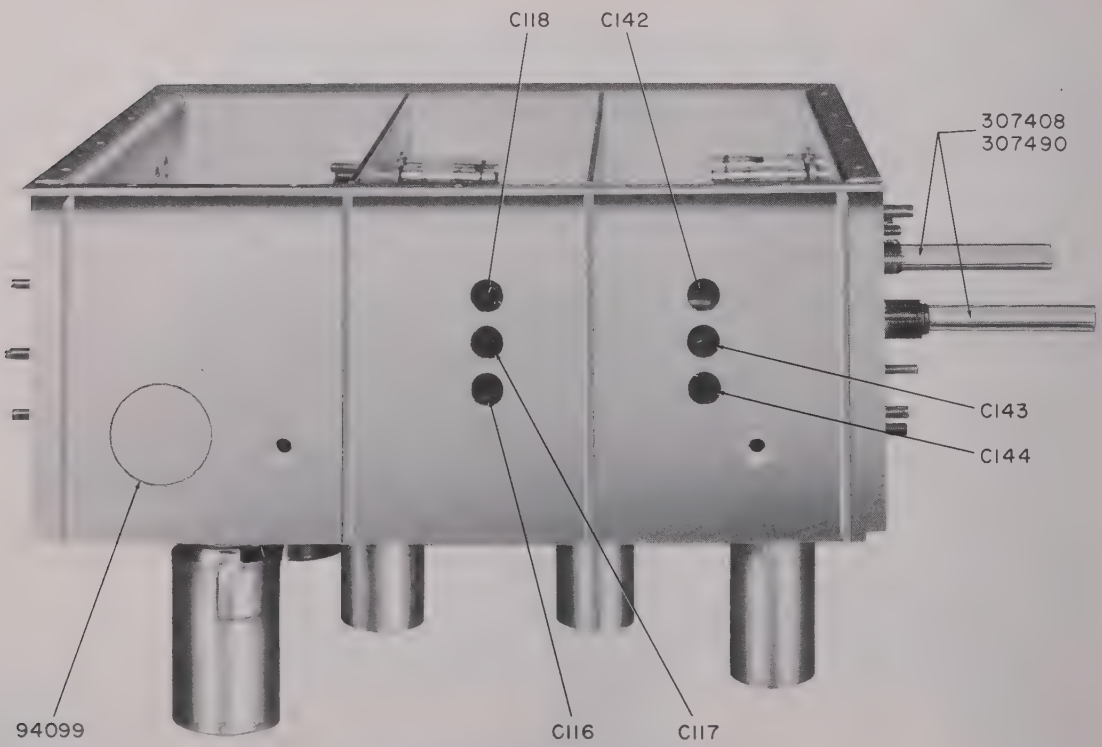



*Figure 30. VHF Unit—Left Side View*

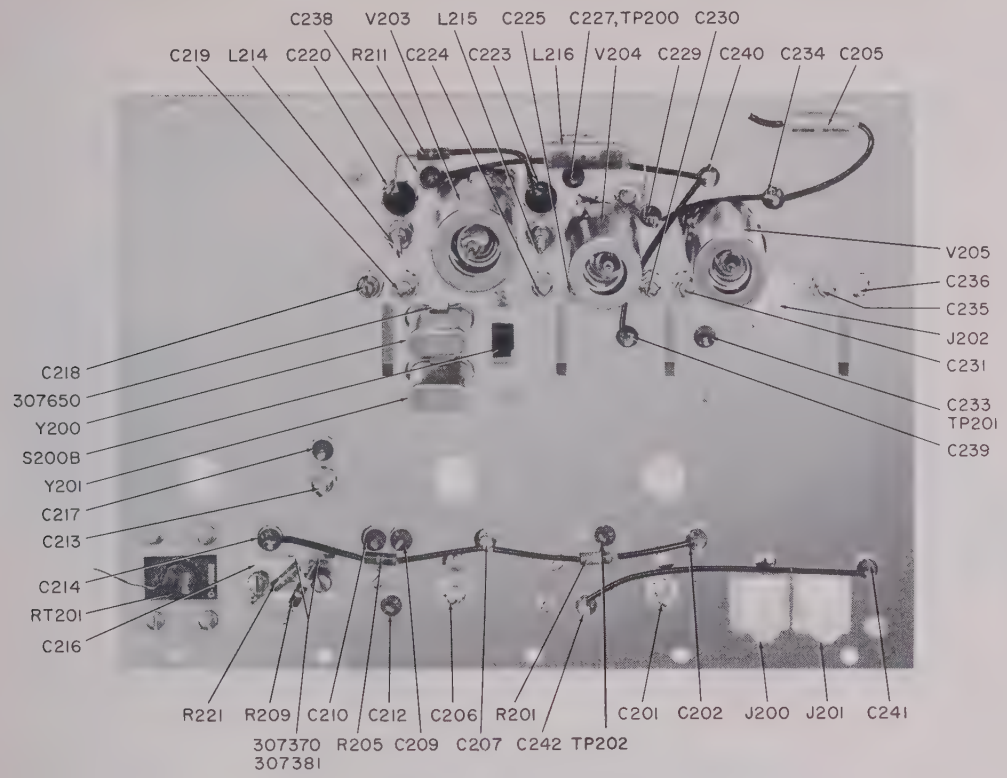



*Figure 31. UHF Unit—Top View*

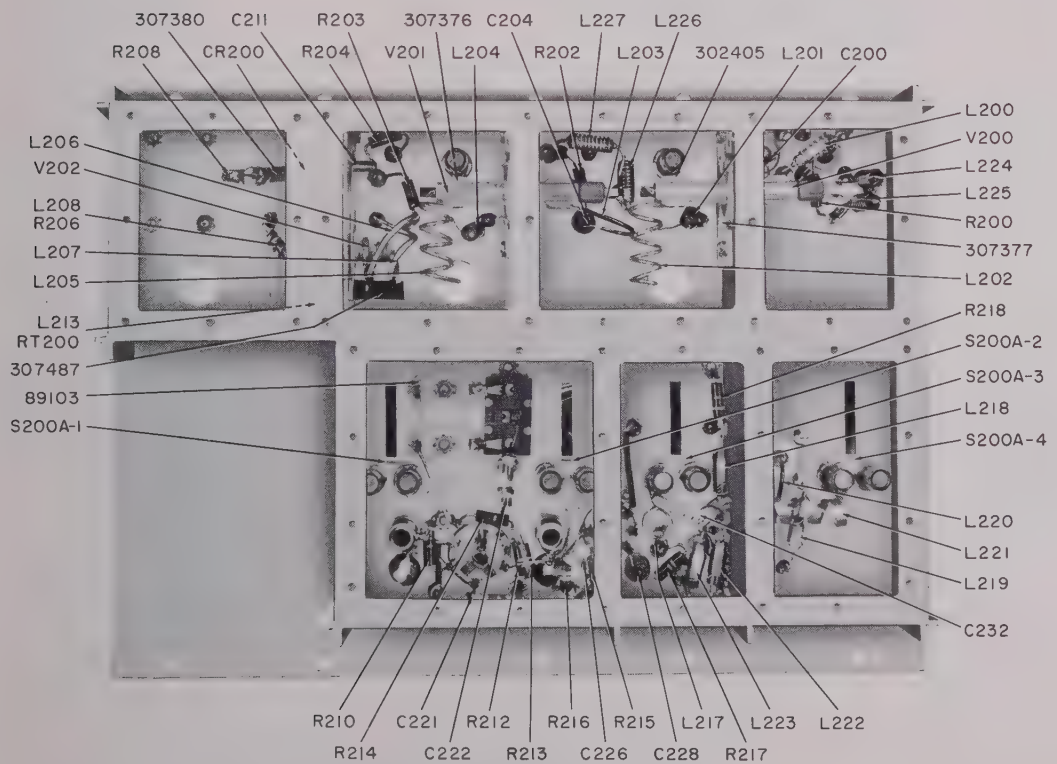



*Figure 32. UHF Unit—Bottom View*

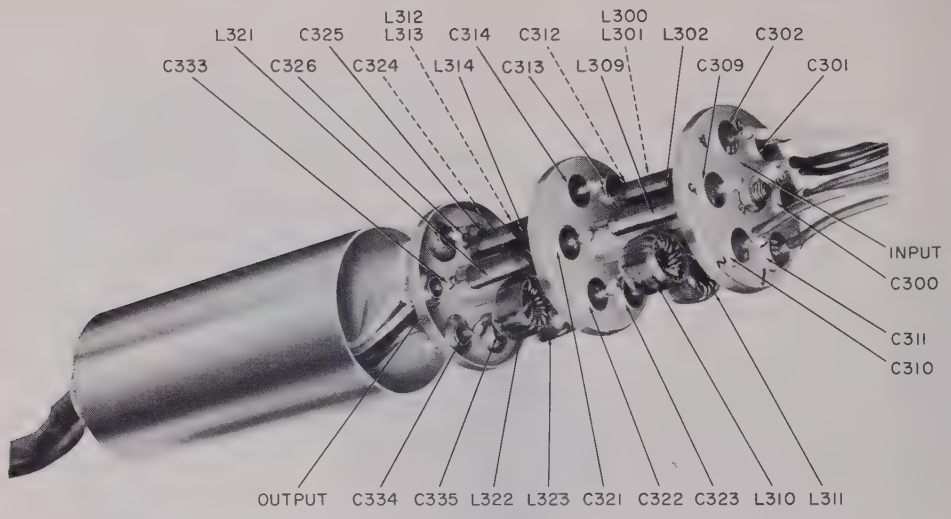



*Figure 33. RF Filter No. 1*

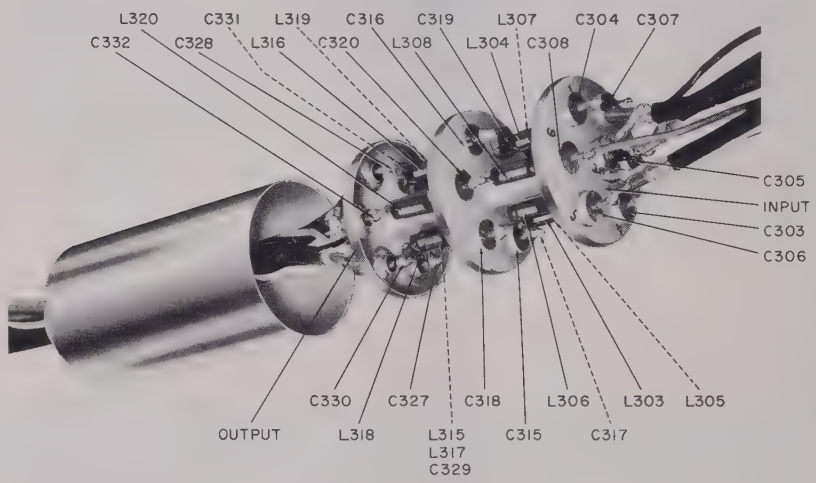



*Figure 34. RF Filter No. 2*

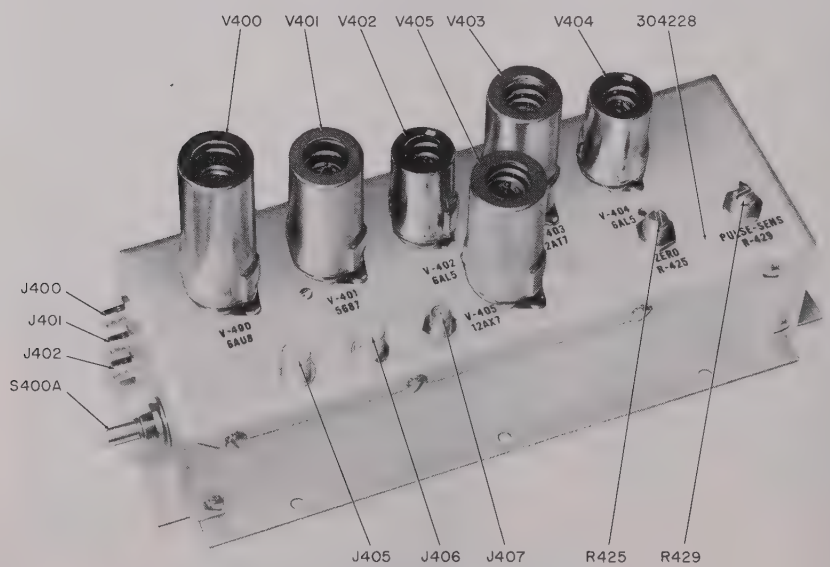



*Figure 35. Pulse Voltmeter—Top View*

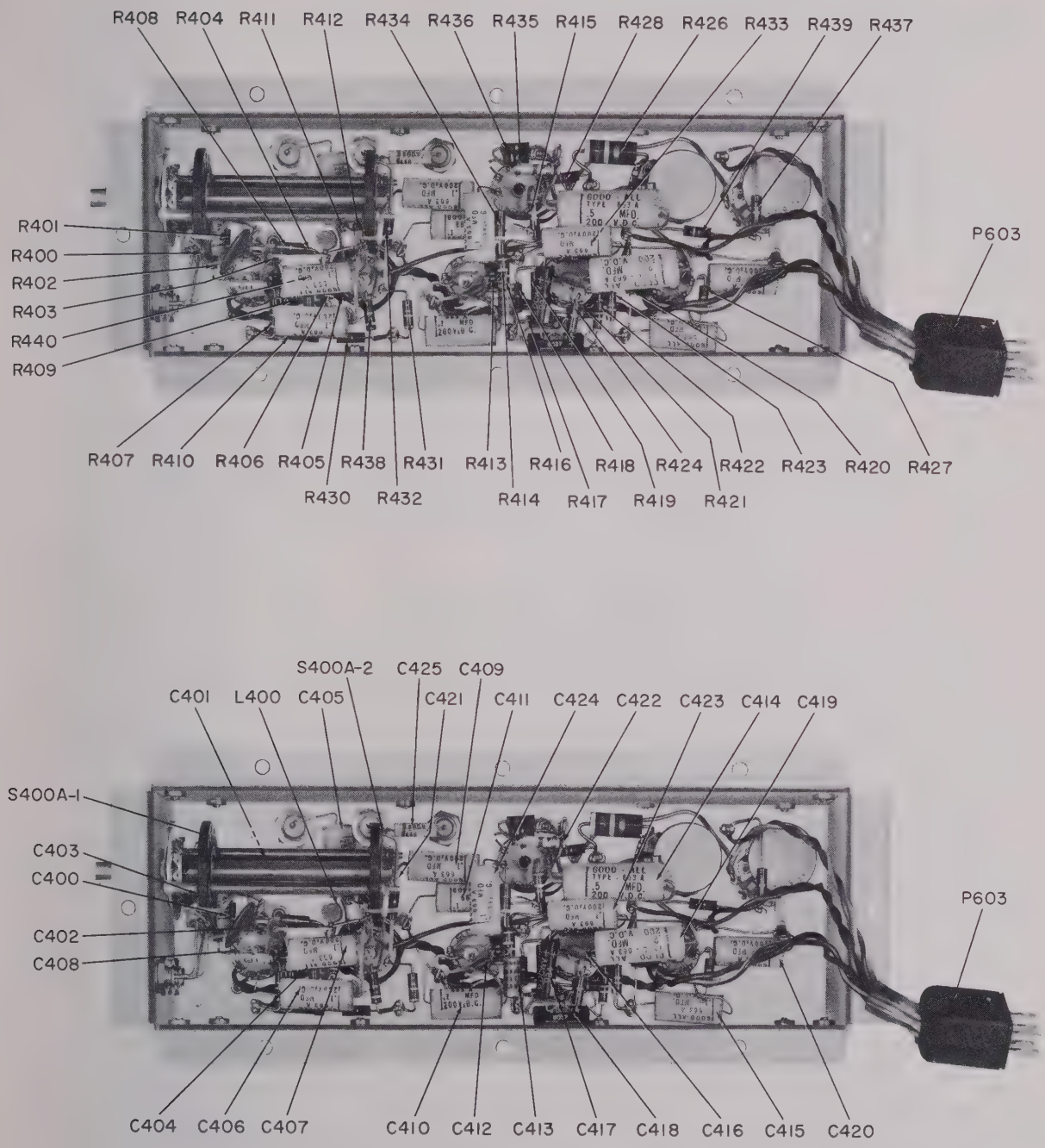



*Figure 36. Pulse Voltmeter—Bottom View*

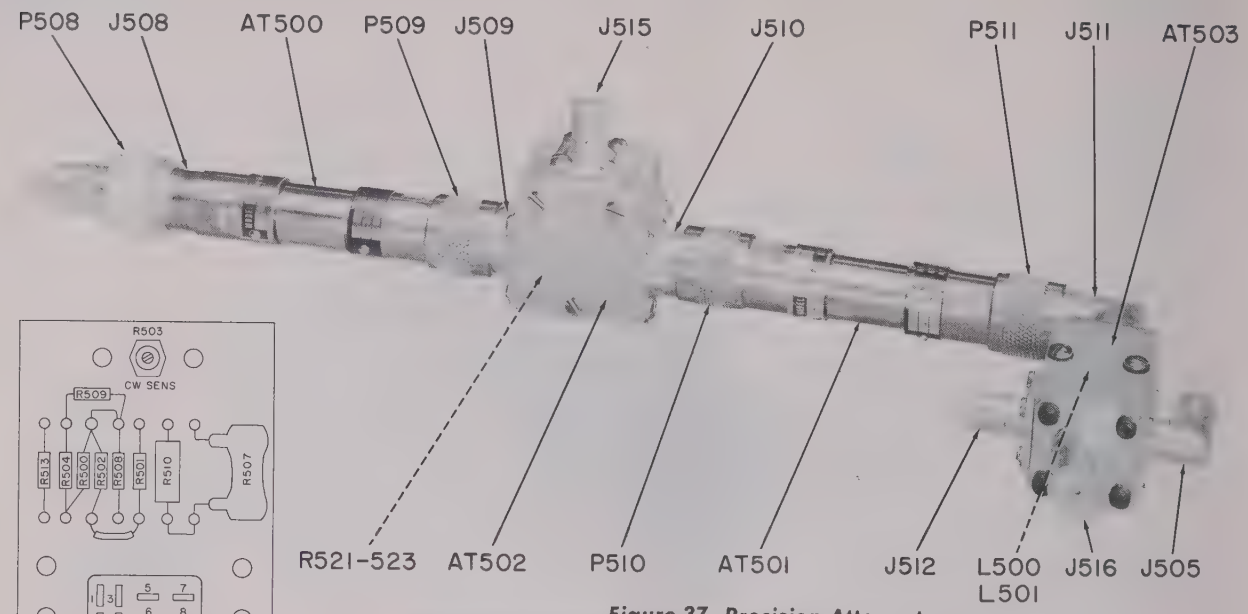



*Figure 37. Precision Attenuator*

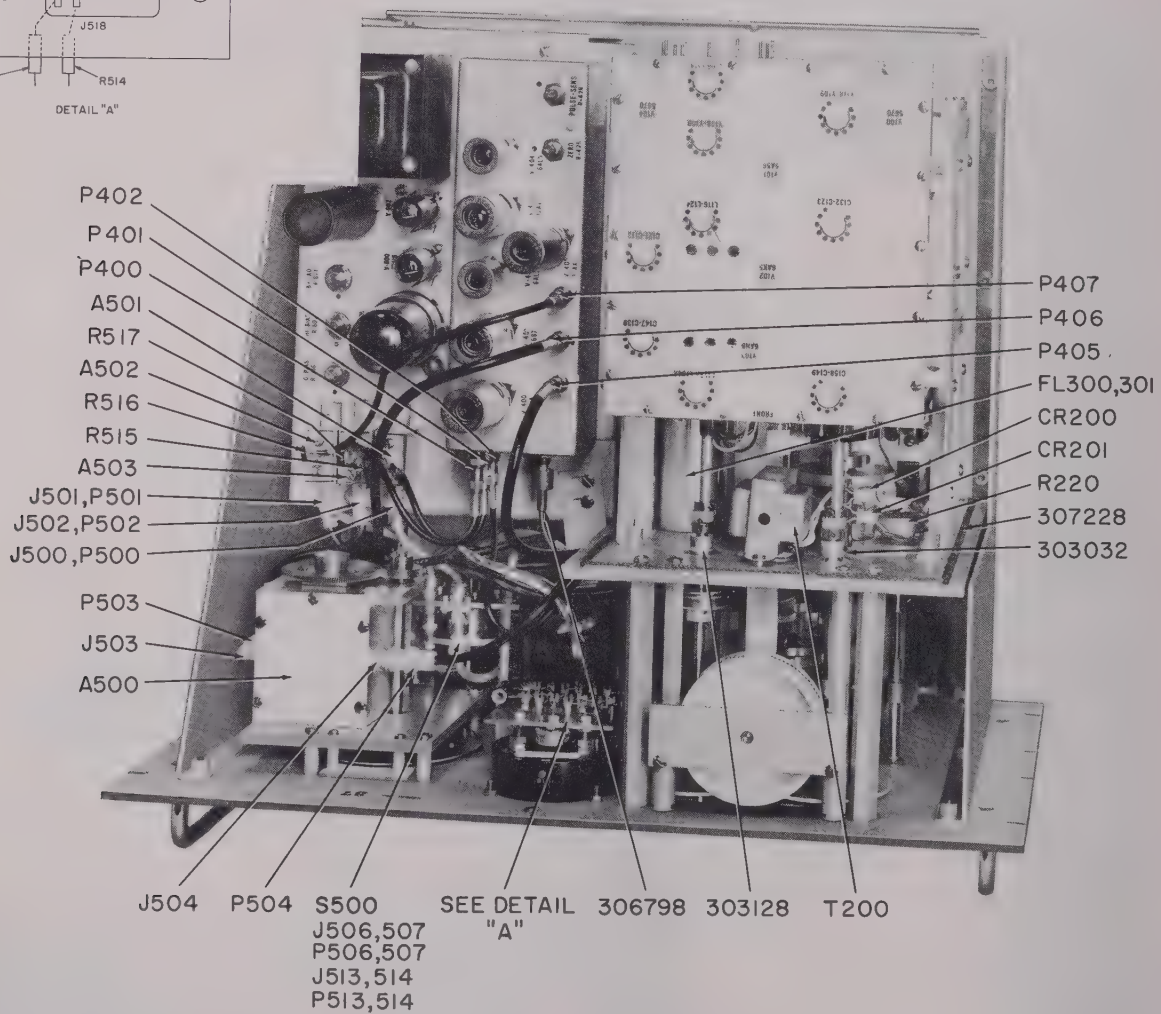



*Figure 38. Type 235A—Top View*

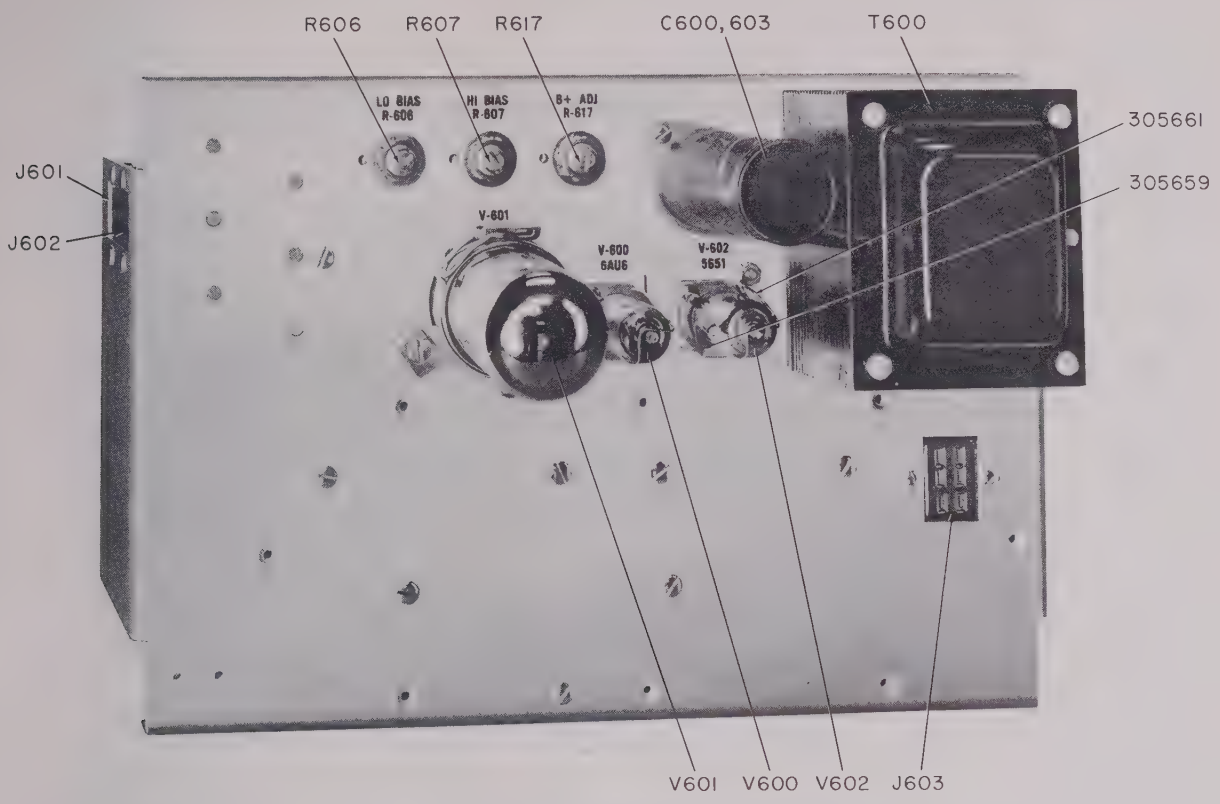



*Figure 39. Power Supply—Top View*

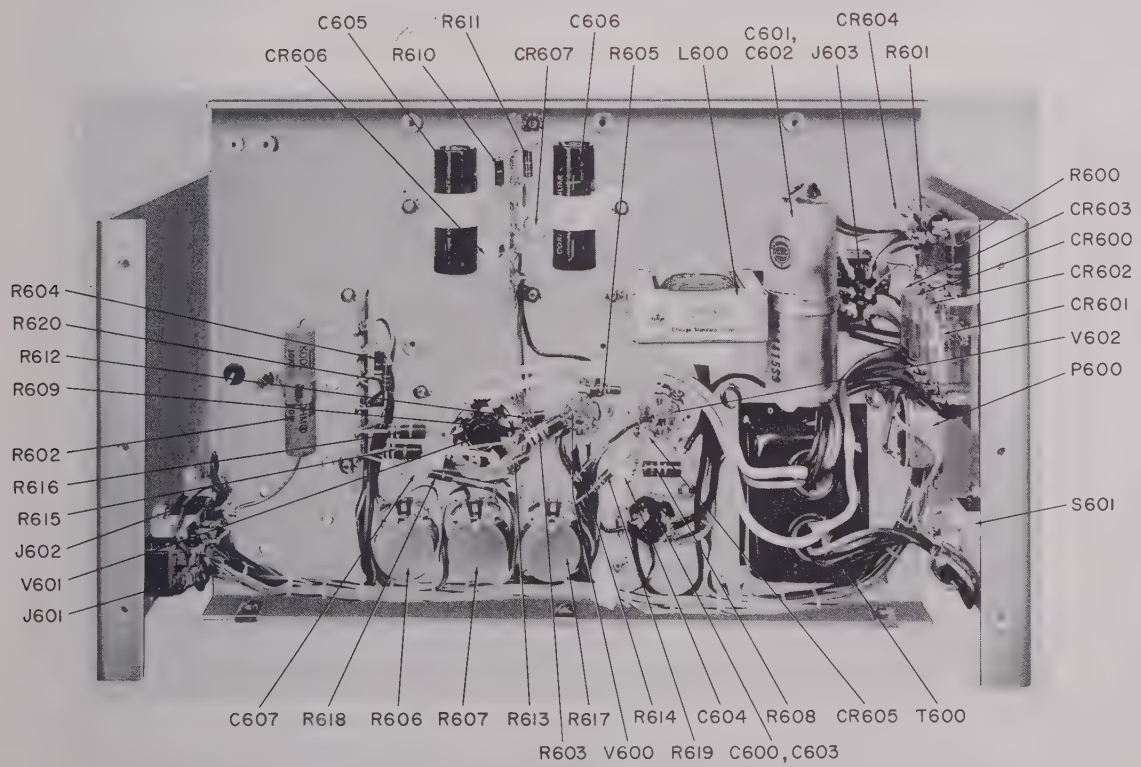



*Figure 40. Power Supply—Bottom View*

## TABLE OF REPLACEABLE MECHANICAL PARTS

| BRC PART NO. | DESCRIPTION | QTY. PER UNIT |
|---|---|---|
| 89075 | Shield, Electron Tube (V101, 102) | 2 |
| 89088 | Shield, Electron Tube (V203) | 1 |
| 89103 | Socket, Crystal | 2 |
| 89111 | Socket, Electron Tube: Octal (V601) | 1 |
| 89112 | Socket, Electron Tube: 7 pin miniature, Bottom Mtg. (V105) | 1 |
| 89135 | Base, Tube Shield (V105) | 1 |
| 91300-1 | Shield, Electron Tube (V204, 205, 402, 404) | 4 |
| 91300-3 | Shield, Electron Tube (V100) | 1 |
| 91300-4 | Shield, Electron Tube (V401, 403, 405) | 3 |
| 91300-6 | Shield, Electron Tube (V400) | 1 |
| 93152 | Ball, Steel | 3 |
| 94025 | Foot, Rubber | 4 |
| 94099 | Plug Button | 1 |
| 94285 | Coupling, Flexible | 1 |
| 300080 | Washer, Spring | 6 |
| 300508 | Terminal, Insulated | 2 |
| 300161 | Socket, Electron Tube: 9 pin miniature | 7 |
| 300162 | Socket, Electron Tube: 7 pin miniature | 6 |
| 300810 | Spring Wiper Assembly | 1 |
| 302231 | Socket, Sub-miniature (V200, 201) | 2 |
| 302337 | Spring Leaf | 4 |
| 302405 | Clip, Fuse | 4 |
| 303032 | Coupling Flexible | 2 |
| 303128 | Spring Wiper Assembly | 2 |
| 303179 | Ring, Retaining | 11 |
| 303222 | Gasket, Shielding | 2 |
| 303876 | Lampholder | 1 |
| 303964 | Clamp, Cord | 2 |
| 304228 | Terminal, Stand-off | 11 |
| 304686 | Spring, Helical Extension | 2 |
| 305659 | Retainer, Electron Tube | 2 |
| 305661 | Retainer, Electron Tube | 2 |
| 305664 | Socket, Electron Tube: 7 pin Miniature (V600, 602) | 2 |
| 306136 | Gear, Bevel | 2 |
| 306511 | Fuseholder | 1 |
| 306577 | Knob | 2 |
| 306582 | Knob | 1 |
| 306582-1 | Knob | 1 |
| 306585 | Knob | 1 |
| 306585-2 | Knob | 2 |
| 306588 | Knob | 1 |
| 306616 | Knob | 1 |
| 306711 | Gear Assembly, Speed Decreaser | 1 |
| 306712-1 | Cam, Internal: Low Range | 1 |
| 306712-2 | Cam, Internal: Low Range | 1 |
| 306712-3 | Cam, Internal: Low Range | 1 |
| 306713-1 | Cam, External: High Range | 1 |
| 306713-2 | Cam, External: High Range | 1 |
| 306713-3 | Cam, External: High Range | 1 |
| 306714 | Gear, Spur | 1 |
| 306715 | Gear, Spur | 1 |

| BRC PART NO. | DESCRIPTION | QTY. PER UNIT |
|---|---|---|
| 306716 | Gear, Spur | 1 |
| 306798 | Shaft, Flexible: with adapters | 1 |
| 306865 | Attenuator Dial Assembly | 1 |
| 306867 | Spring Wiper Assembly | 1 |
| 306869 | Fiducial, Attenuator | 1 |
| 306883 | Pulley, Grooved: Driver | 2 |
| 306899 | Pulley, Grooved | 1 |
| 306900 | Pulley, Grooved | 1 |
| 306901 | Wire Rope Assembly— Cable | 2 |
| 306903 | Belt, Flat— Band | 2 |
| 306906 | Units Dial Assembly | 1 |
| 306909 | Tens Dial Assembly | 1 |
| 306914 | Guide | 3 |
| 306915 | Mounting Block and Retainer Assembly | 3 |
| 306925 | Arm Assembly, Mask | 1 |
| 306929 | Spring, Torsion | 1 |
| 307000 | Dial, Drum | 1 |
| 307085 | Detent | 3 |
| 307215 | Follower Block Assembly | 3 |
| 307228 | Gasket, Shielding | 1 |
| 307250 | Collar and Spring Assembly | 6 |
| 307252 | Collar and Finger Assembly | 1 |
| 307267 | Mask, Fiducial | 1 |
| 307276 | Flexible Shaft Assembly | 1 |
| 307370 | Plate, Diode | 1 |
| 307376 | Clip and Contact Tab Assembly | 2 |
| 307377 | Contact | 4 |
| 307380 | Contact | 1 |
| 307381 | Insulator | 1 |
| 307395 | Spring, Compression | 1 |
| 307408 | Shaft and Detent | 2 |
| 307486 | Cable Assembly | 1 |
| 307487 | Socket, Electron Tube | 1 |
| 307490 | Wiper Assembly | 2 |
| 307514 | Arm Assembly | 2 |
| 307516 | Arm Assembly | 1 |
| 307534 | Tuning Rod Assembly | 2 |
| 307535 | Tuning Rod Assembly | 1 |
| 307540 | Collar and Pin Assembly | 2 |
| 307560 | Clamp, Tube (V601) | 1 |
| 307563 | Knob | 1 |
| 307569 | Cable Assembly | 1 |
| 307570 | Cable Assembly | 1 |
| 307572 | Spring Wiper | 3 |
| 307577 | Cable Assembly | 2 |
| 307578 | Cable Assembly | 1 |
| 307579 | Cable Assembly | 1 |
| 307580 | Cable Assembly | 1 |
| 307582 | Piston Glass Assembly | 3 |
| 307634 | Collar, Range Switch Assembly | 4 |
| 307650 | Clip, Electrical | 2 |
| 307660 | Cable Assembly: Type 521A | 1 |
| 307663 | Cable Assembly: Type 522A | 1 |
| 308034 | Shaft and Gear Assembly | 1 |
| 308035 | Gear | 1 |
| 308332 | Spring, Gear | 2 |
| 308503 | Clamp, hub | 6 |

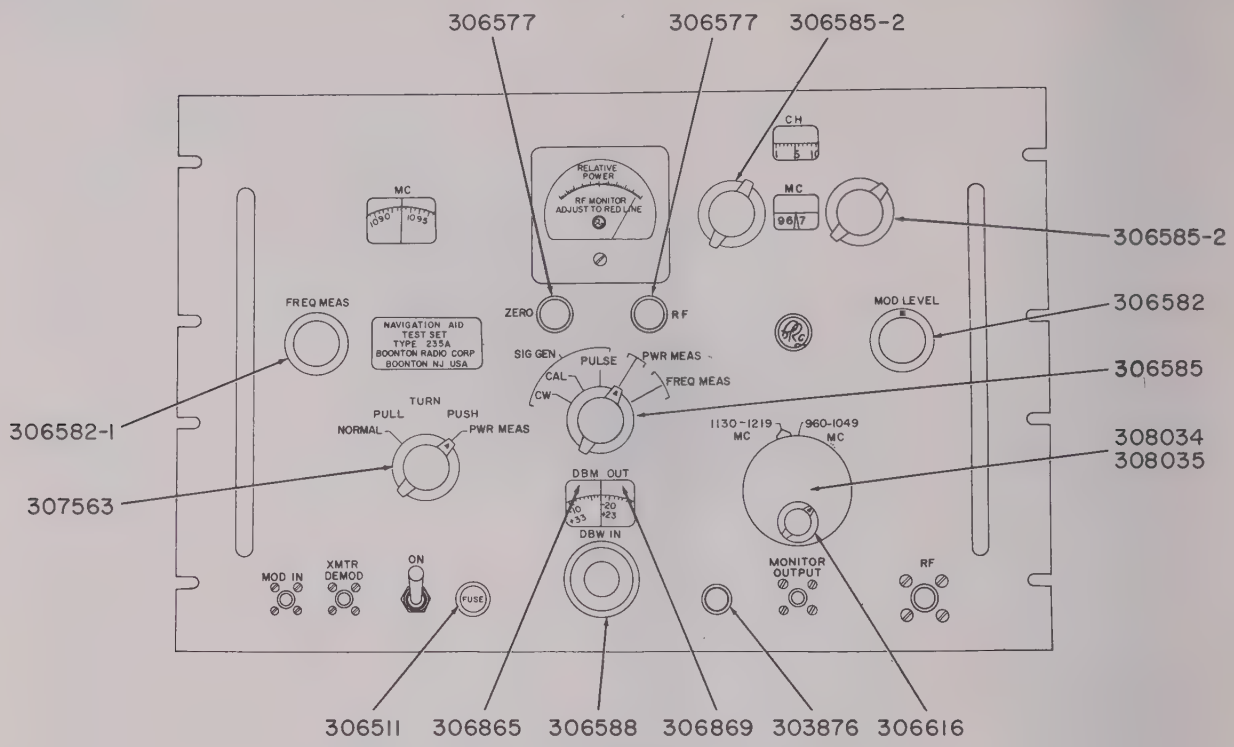



*Figure 41. Front Panel Knobs*

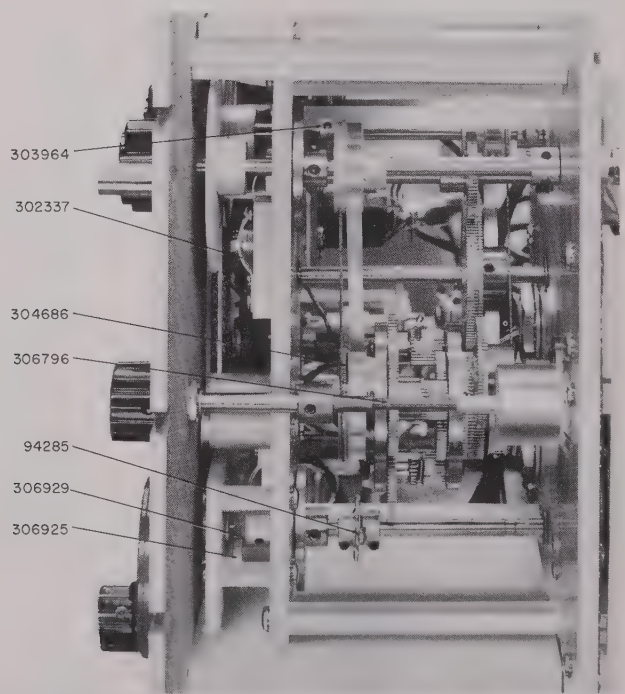



*Figure 42. Gear Assembly—Right Side View with Front Panel*

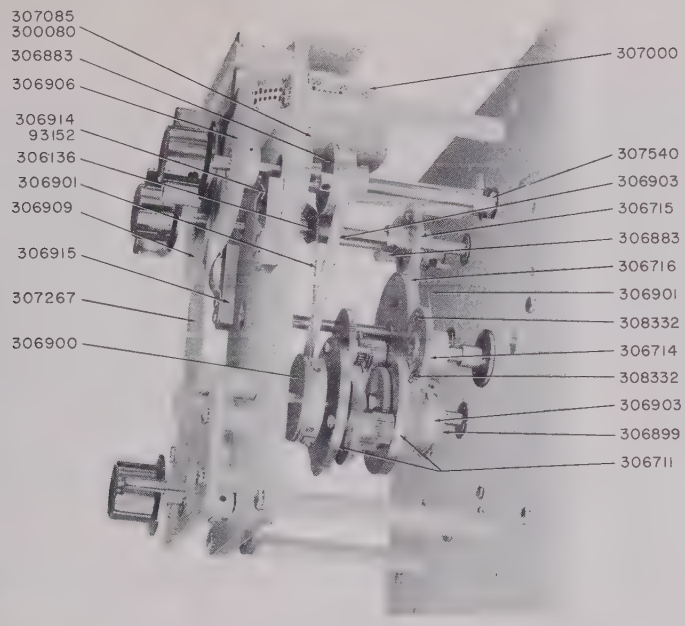



*Figure 43. Gear Assembly—Right Side View*

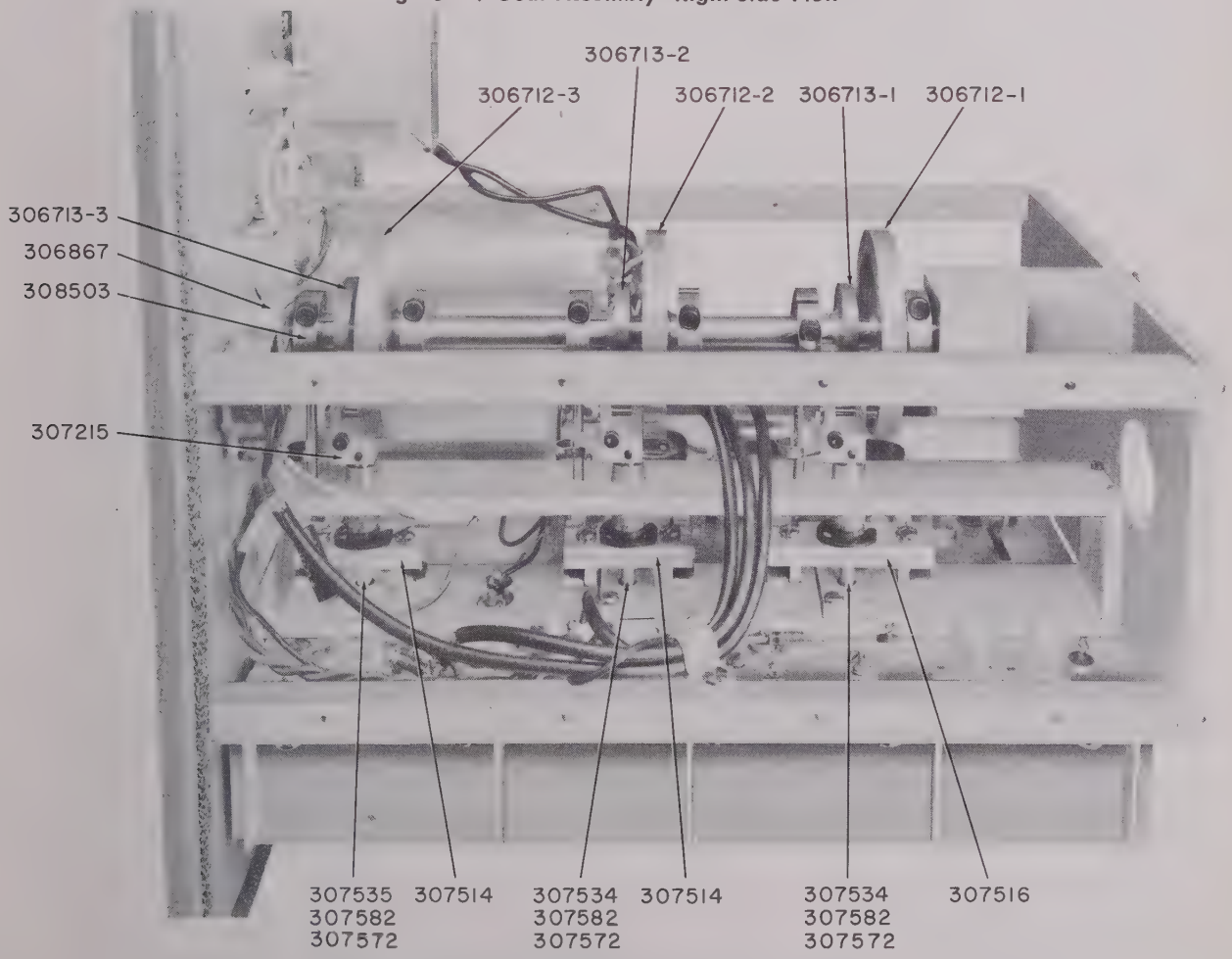



*Figure 44. RF Unit Cam Assembly—Right Side View*

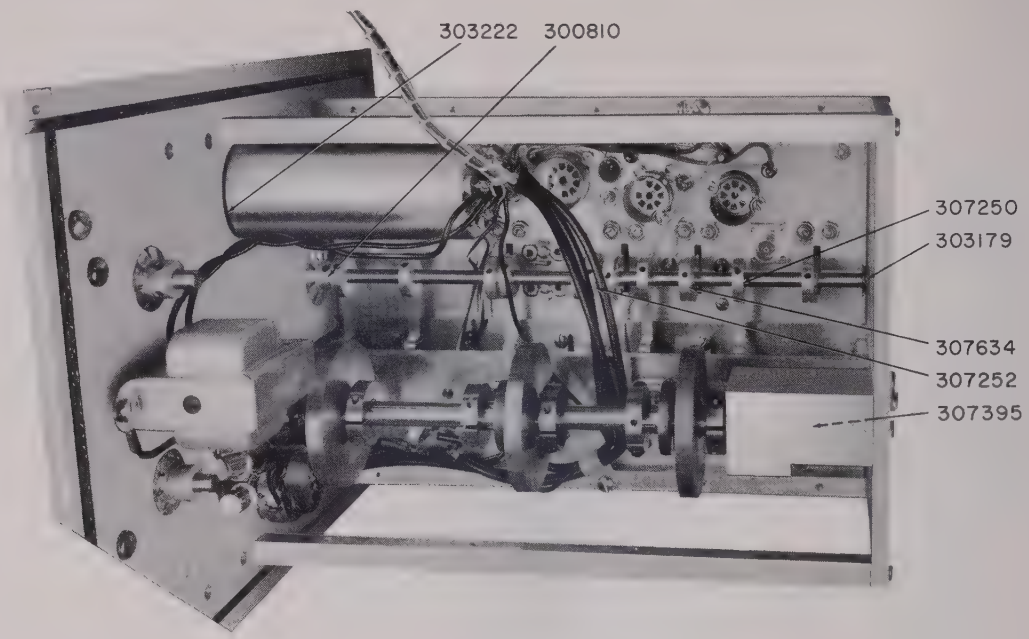



*Figure 45. RF Unit Cam Assembly—Top View*

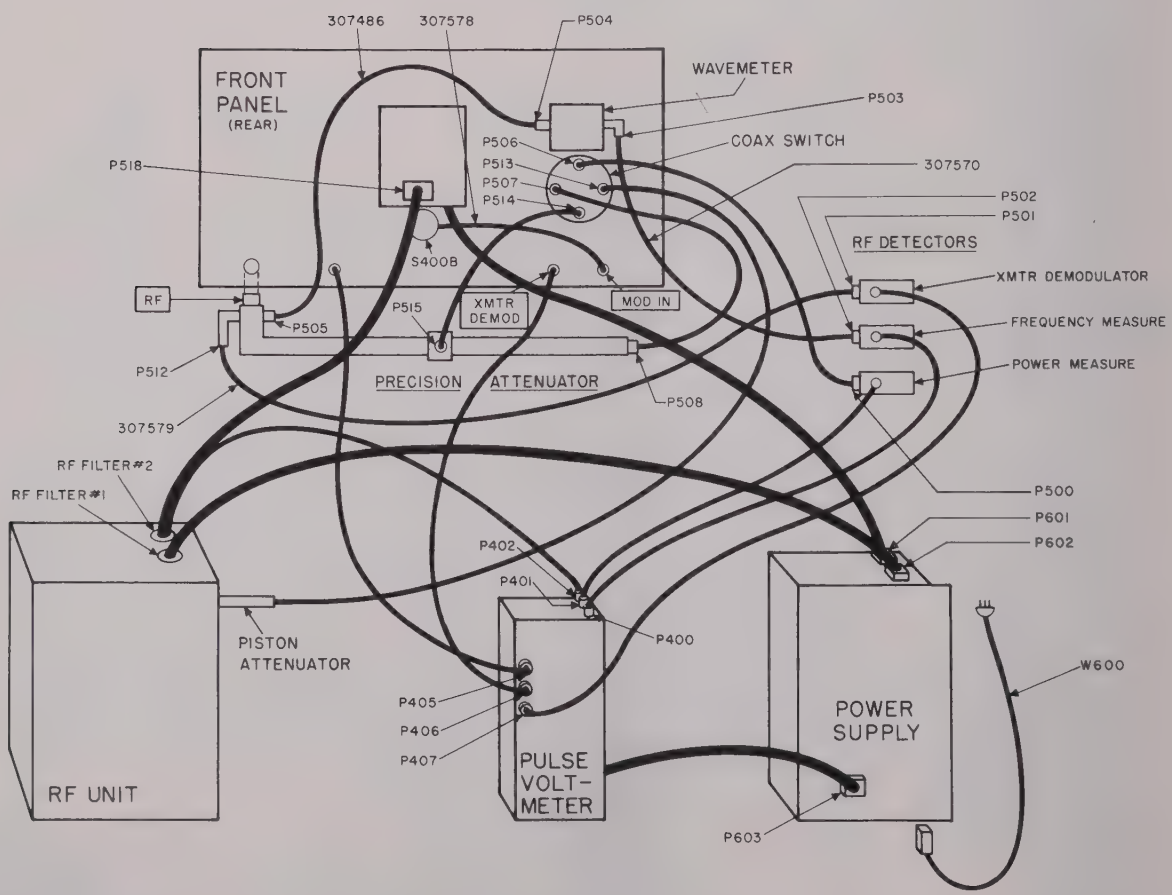
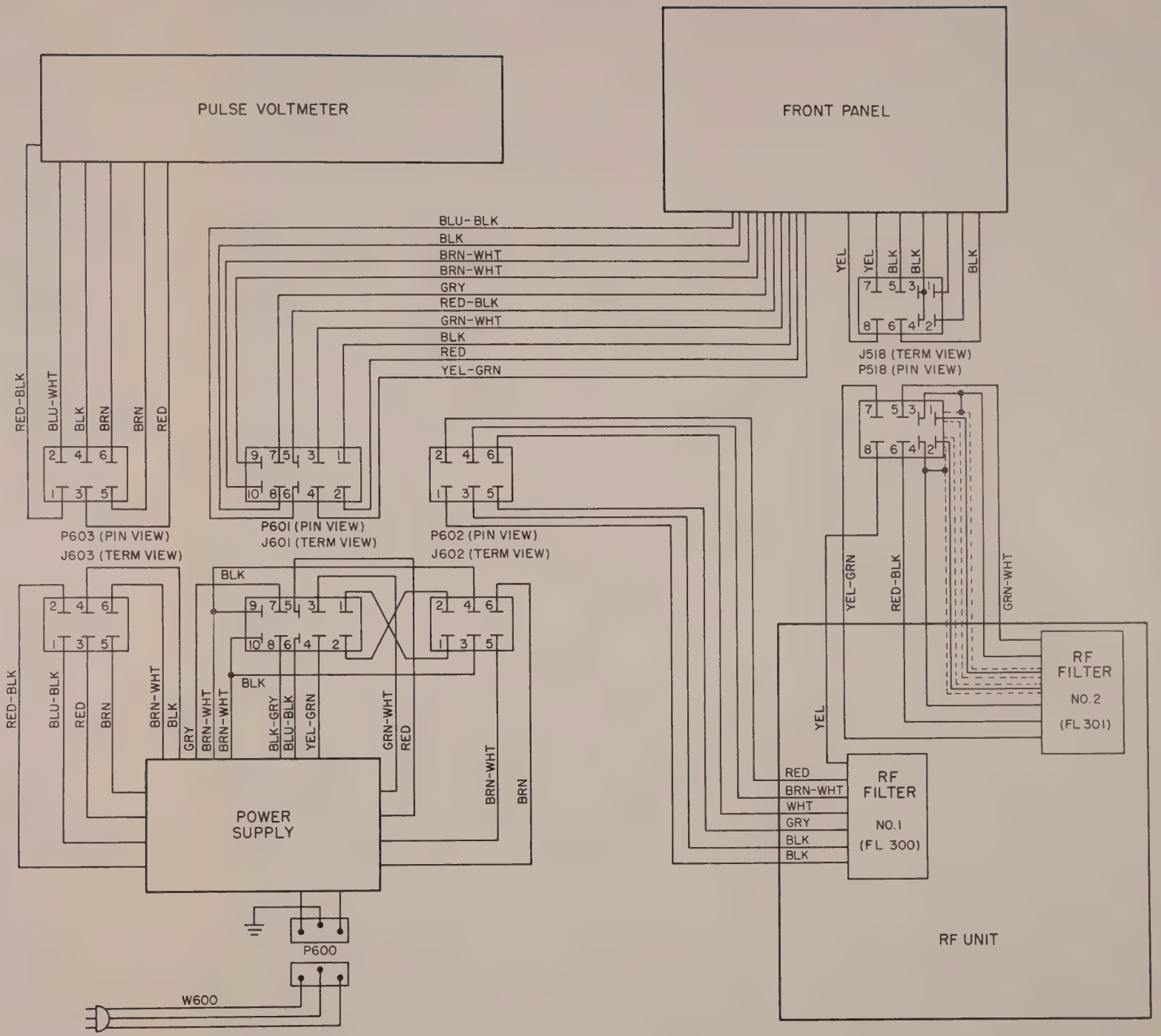


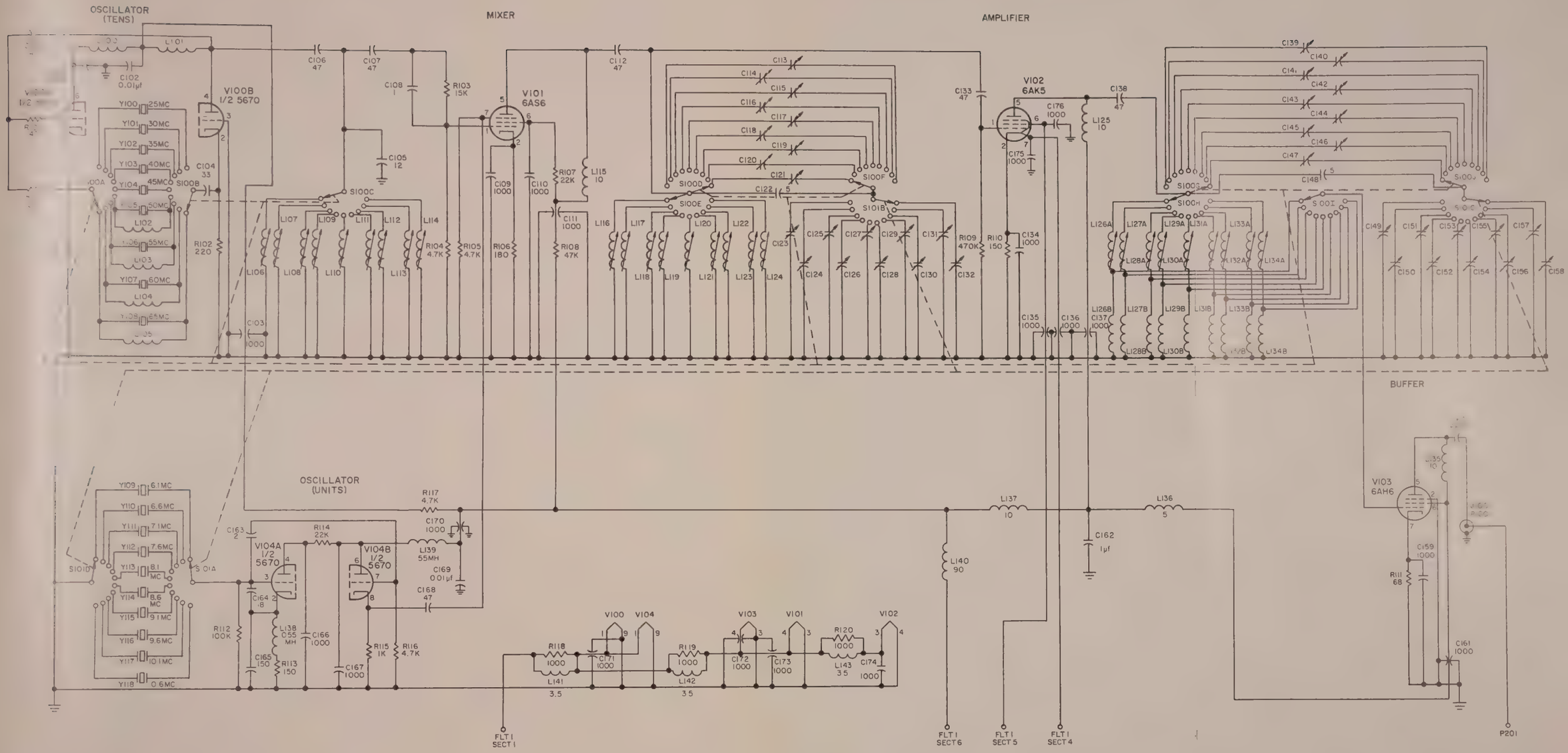

*Figure 46. Interconnecting Cables—Type 235A*




**NOTES**

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.

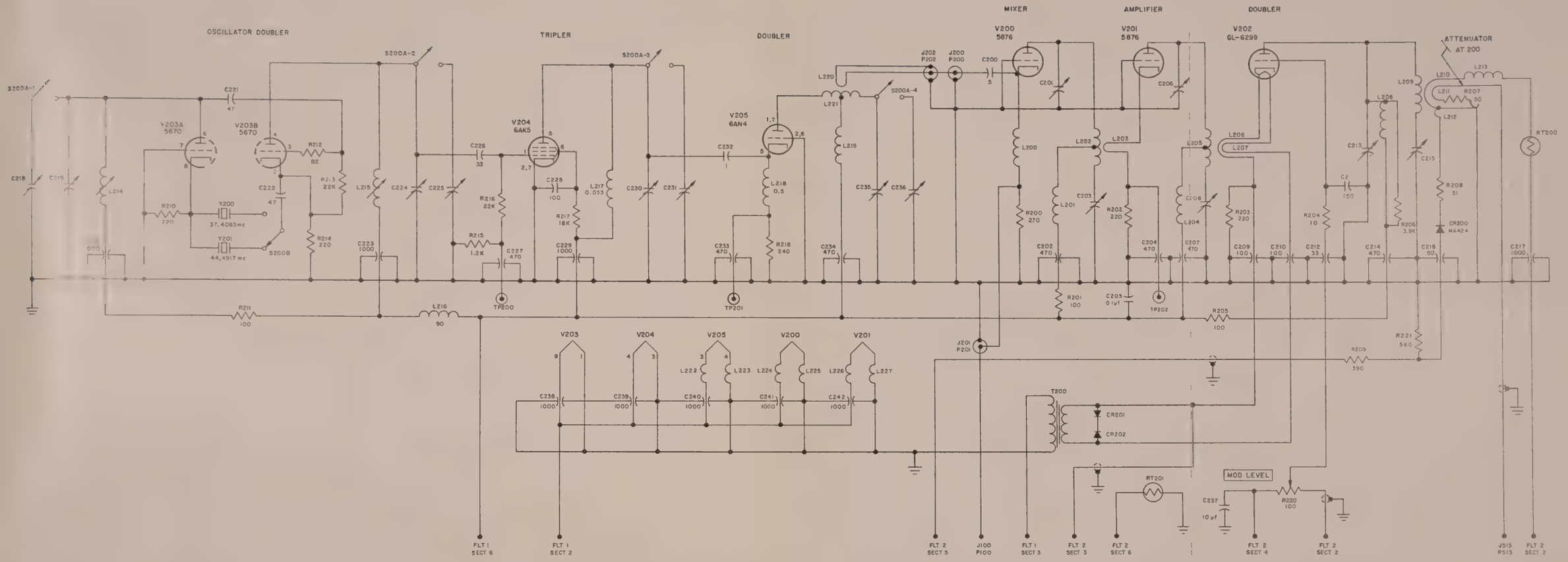
*Figure 47. Multiple Cable Wiring Diagram*




## NOTES

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.

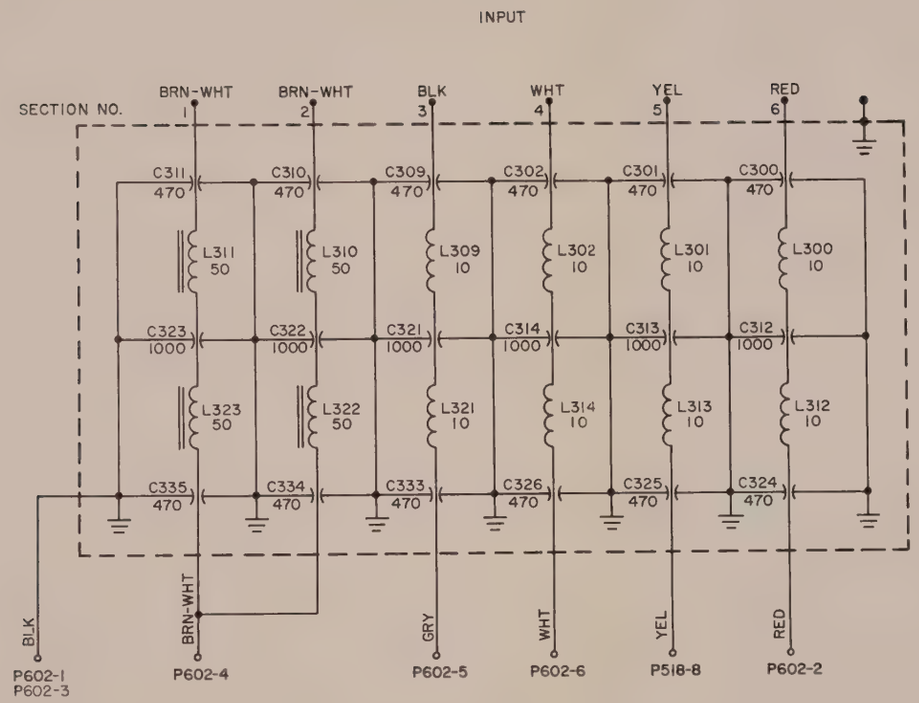
*Figure 48. Schematic Diagram—VHF Unit*



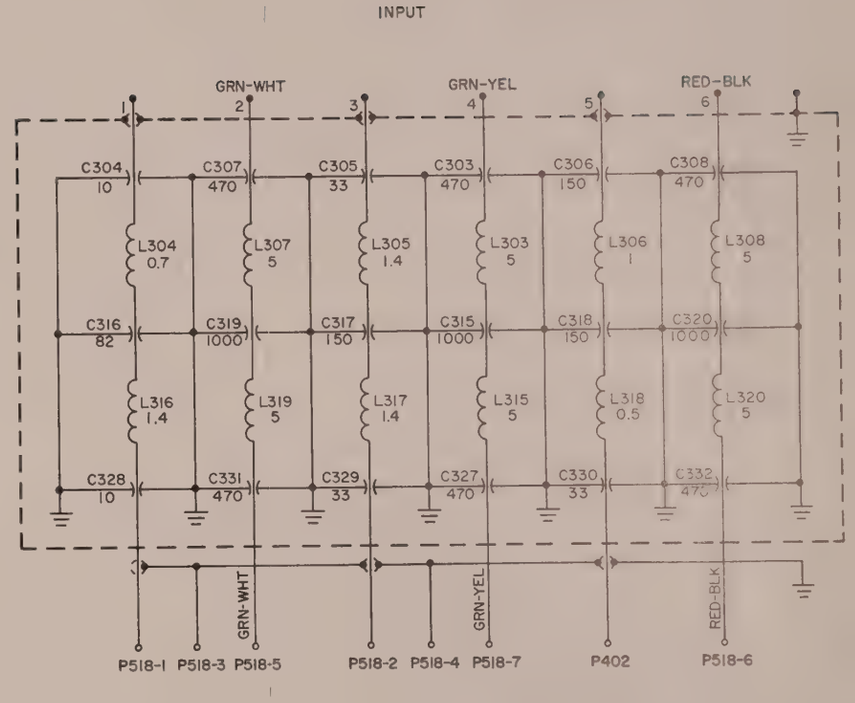

## NOTES

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.
4. S200A, S200B, C203, C208, and C215 are ganged to the Frequency Range Switch.

*Figure 49. Schematic Diagram—UHF Unit*




FILTER NO.1 (FL 300)

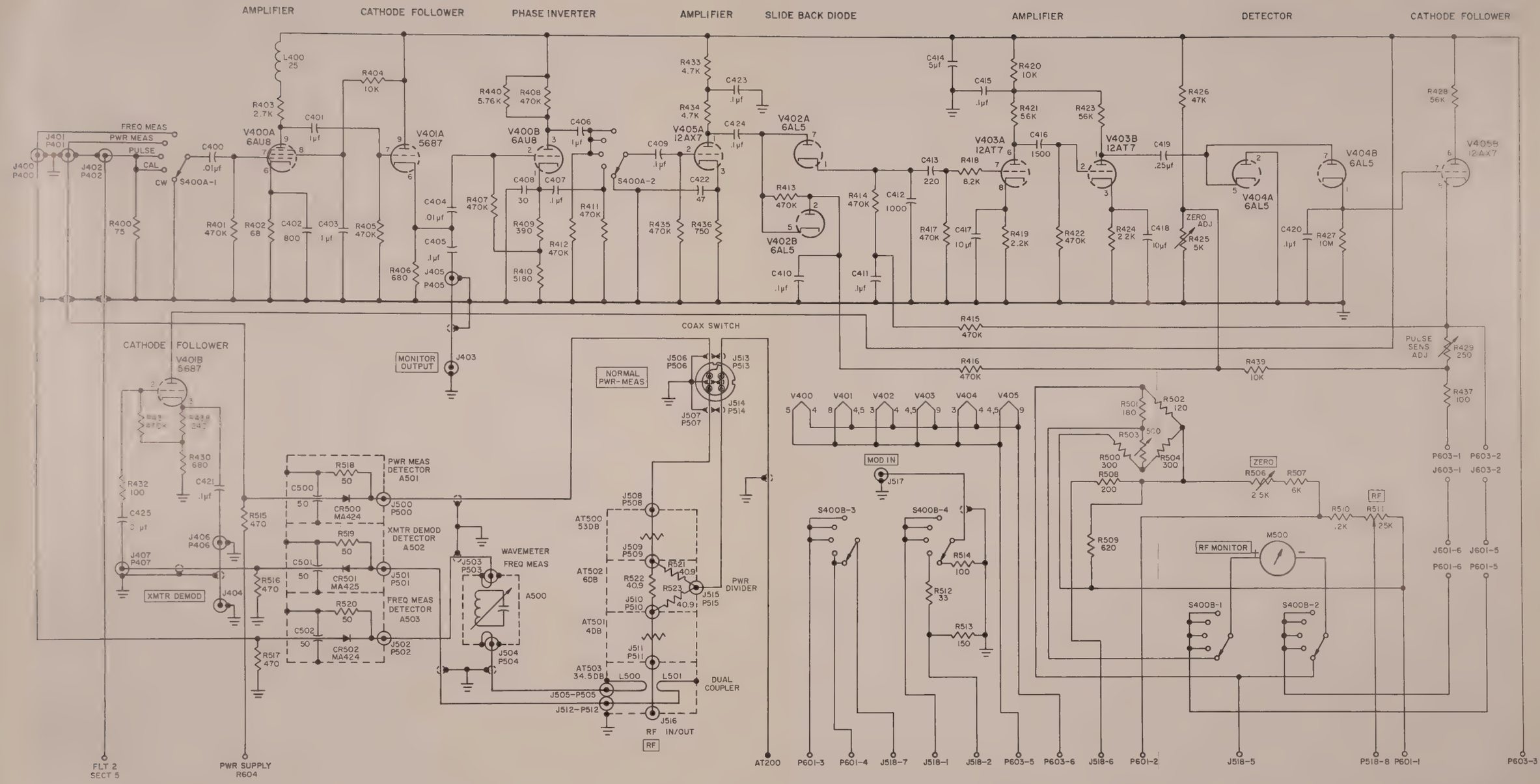



FILTER NO.2 (FL 301)

**NOTES**

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.

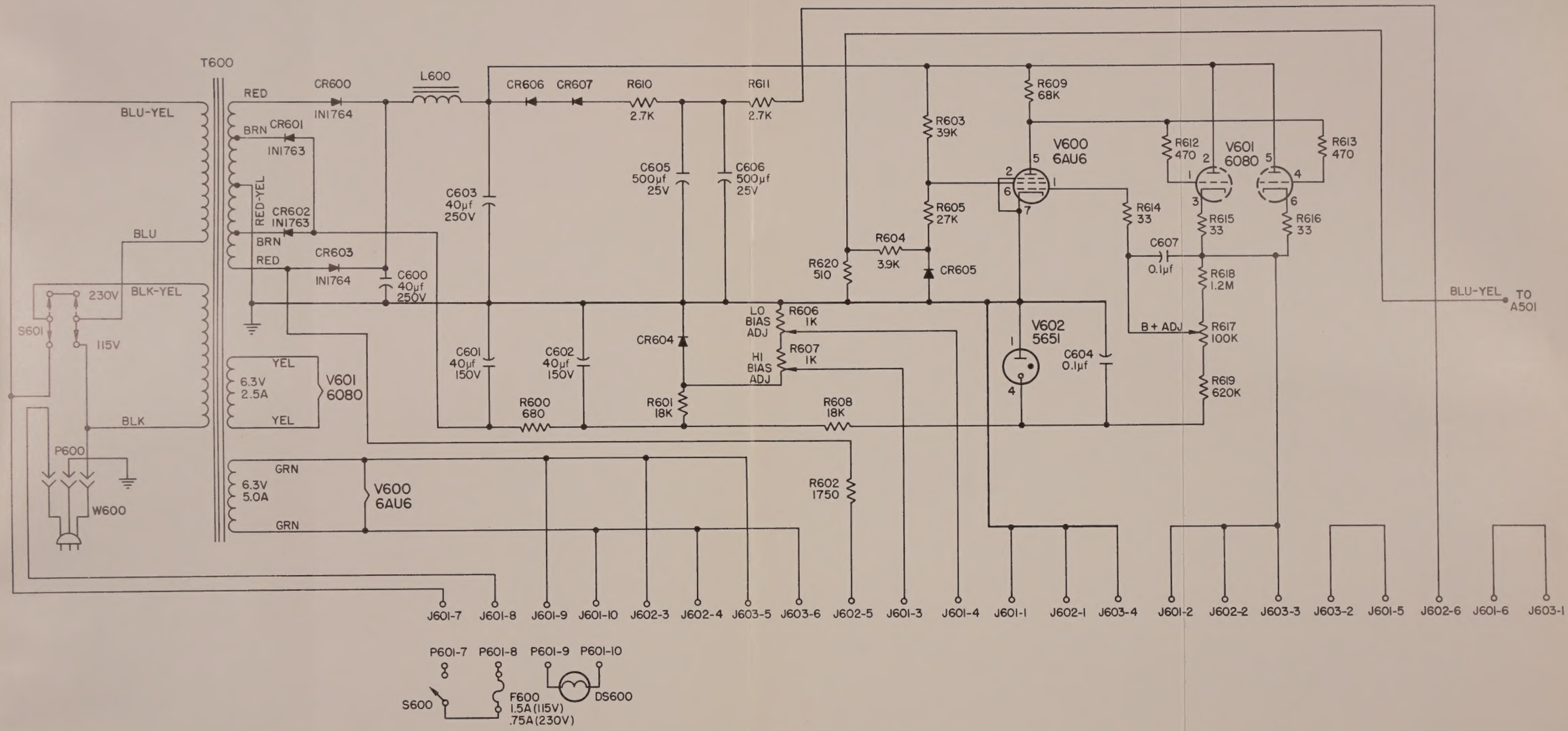
***Figure 50. Schematic Diagram—RF Filters***




**NOTES**

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.

***Figure 51. Schematic Diagram—Pulse Voltmeter and Associated Circuitry***




**NOTES**

1. Unless otherwise indicated resistance is in ohms, capacitance is in picofarads, and inductance is in microhenries.
2. □ Indicates front panel control.
3. P000-0 indicates plug P000, terminal number 0.

*Figure 52. Schematic Diagram—Power Supply*

MP MASTER
MA24332